RE-CONTROL THE MARKET FOR STRATEGIC POWER:

CHINA'S REREGULATION OF ITS RARE EARTH INDUSTRY

A Dissertation
Presented to
The Academic Faculty

by

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In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in International Affairs, Science and Technology in the
Sam Nunn School of International Affairs

Georgia Institute of Technology
August 2016

RE-CONTROL THE MARKET FOR STRATEGIC POWER:

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ACKNOWLEDGEMENTS

I would like to start by thanking my thesis advisor Fei-Ling Wang for believing in my project from the very beginning and for believing in my ability to carry it through. Dr. Wang guided me through this project with unwavering support and wise shepherding. This PhD dissertation would not exist without his thoughtful guidance, customized mentorship, and close reading. I am also deeply indebted to his encouragement and advocacy, always timed to when I need them the most, his pragmatic advice about both scholarship and professional development, and his generous time and patience with me throughout my PhD years. His exceptional commitment to scholarship, excellence in teaching, and passion for the study of the political economy of China has been a true inspiration to me.

My next indebtedness is registered to my committee members. I thank John Garver for his many insightful conversations about Chinese politics and political economy, for his kind support and recommendation for funding applications, and for providing me critical feedback on various versions of the draft. I thank Margaret Kosal for her interest starting in the early stage of this project, and for always asking probing questions that lead to enlightening discussions and interesting findings. I thank John McIntyre at the Scheller School of Business for teaching me International Business Environment, for providing opportunities to present my research to the business community, and for always being available for encouragement, valuable advice and information on both the thesis topic and on professional development. I thank Jane Nakano at the Center for Strategic and International Studies in Washington D.C. for sharing with me her expert views on energy and resource policy in both the U.S. and Asia, for making the time to discuss the project with me since the early stages of writing, and for giving me sound advice about professional development.

The Sam Nunn School of International Affairs and Georgia Tech provided me a caring and dynamic environment for learning which shaped my interdisciplinary research and intellectual interests. I thank Dr. Brian Woodall for showing me example of a great teacher imparting knowledge to students as a teaching mentor, for expanding my understanding about Japan and East Asia, and for support for my research and travel while directing the program. I thank Dr. Kirk Bowman for teaching me Comparative Politics, and for his valuable advice for this project when teaching me Research Design. I thank Dr. Esther Skelley Jordan and Dr. Peter Brecke for sound advice in empirical research methods, teaching pedagogy, and kind encouragement for my professional growth. I thank Dr. Alasdair Young for the opportunity to assist his research on the WTO and the European Union, thereby expanding my knowledge about global trade issues and the WTO disputes. I thank Dr. Katja Weber and Dr. Jenna Jordan for teaching me International Affairs and for their warm support and feedback for me at several stages of the research project. I thank Dr. Michael Best and Dr. Mark Zachary Taylor for checking in on my progress and providing support for research and conference travel while directing the graduate program. I thank Assistant Director Vince Pedicino for always providing critical support and help throughout the PhD study. I feel very grateful for the intellectual support and emotional affinities from my PhD cohort, especially Tong Zhao and Jonathan Huang who set a high standard for my work and had many delightful conversations with me about PhD research and Chinese politics. I thank Dr. David

Lawrence at the Center for the Enhancement of Teaching and Learning (CETL) for teaching me writing and online communications, and for giving me practical advice about communicating my research to different audiences.

This project would not have succeeded without generous financial and institutional support from several agencies. I thank the Horowitz Foundation for supporting this dissertation project through the generous Horowitz Foundation for Social Policy Grant. I thank the the support of the Ford Foundation-funded New Generation China Scholars Program at my local affiliation the University of Chicago Center in Beijing, in particular Prof. Dali Yang, Prof. William Parish, Manager Xueming Liang, and fellow scholars and staff members at the Center.

In China and the U.S. many scholars and professionals have kindly provided expert knowledge at various stages of my project, as well as friendship and support in field work. Those who I can name include Gareth Hatch, James Hedrick, Rosalyn Hsueh, Bruce Dickson, Jost Wuebbeke, Matthew Baltz, David Abraham, Eve Bower, May Tan-Mullins, Guo Chaoxian, Zhu Yongfeng, Chen Zhanheng, Yan Chunhua, Liu Weihua, Wu Yiding. Many more industry professionals and government employees, classmates at my alma mater Peking University College of Chemistry, and friends at local regions have opened door to me to serve as interviewees, informants, helpers, personal introduction, often on anonymous basis, for which I feel deeply indebted to.

Finally I thank my mother and father, without whose emotional support I would not be here. Growing up in China, I feel privileged to be born into a family that embraces both the traditions of hard work for education and the openness to take detours to explore different disciplines, languages and cultures. Their decades of work experience for state-

owned companies instilled in me an early interest in studying the role of the state in China’s development. I am grateful for their profound support and inspirations.

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LIST OF SYMBOLS AND ABBREVIATIONS

ACREI	Association of China Rare Earth Industry
AIC	Administration of Industry and Commerce
APS	American Physical Society
BRIRE	Baotou Research Institute of Rare Earths
CAS	Chinese Academy of Sciences
CAST	China Association of Science and Technology
CCMMC	China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters
CMIEC	China Metallurgical Import & Export Company
CNNC	China National Nuclear Company
COSTIND	China's Commission for Science, Technology and Industry for National Defense
CSRE	Chinese Society of Rare Earths
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
GAO	U.S. Government Accountability Office
GRINM	General Research Institute for Non-ferrous Metals
HEV	Hybrid Electric Vehicle
HREE	Heavy Rare Earth Elements

IPR	Intellectual Property Rights
JOGMEC	Japan Oil, Gas and Metals National Corporation
LREE	Light Rare Earth Elements
M&A	Merger and Acquisition
MEP	China's Ministry of Environmental Protection
METI	Japan's Ministry of Economy, Trade and Industry
MITI	Japan's Ministry of International Trade and Industry (previously METI)
MIIT	China's Ministry of Industry and Information Technology
MLP	Medium and Long-term Plan for China's Science and Technology Development (2006-2020)
MLR	China's Ministry of Land and Resources
MPS	China's Ministry of Public Security
MOF	China's Ministry of Finance
MOFCOM	China's Ministry of Commerce
MOS	China's Ministry of Supervision
MOST	China's Ministry of Science and Technology
MOSP	China's Ministry of Security Protection
MRS	Materials Research Society
NDRC	China's National Development and Reform Commission
NDSTC	China's National Defense Science and Technology Commission
NSFC	Natural Science Foundation of China
NPC	China's National People's Congress
PM	Permanent Magnets
PLA	China's People's Liberation Army
PRC	People's Republic of China

REE	Rare Earth Elements
REO	Rare Earth Oxide
R&D	Research and Development
S&T	Science and Technology
SAIC	China’s State Administration of Industry and Commerce
SASAC	China’s State-owned Assets Supervision and Administration Commission
SEI	Strategic Emerging Industries
SIPO	China’s State Intellectual Property Office
SOE	State-Owned Enterprise
SPC	China’s State Planning Commission
SSTC	China’s State Science and Technology Commission (subsequently MOST)
USCC	United States-China Economic and Security Review Commission
USGS	United States Geological Survey
VAT	Value-Added Tax
WTO	World Trade Organization

SUMMARY

This thesis studies the role and the capacity of the Chinese state in the development of China's rare earth industry. The Chinese rare earth industry has rapidly developed since the late 1970s and has provided the global supply of this group of strategic minerals since the late 1990s. Through interviews, site visits and analysis of archival and secondary data, the study finds that the Chinese central state has long engaged in "reregulation" in industry liberalization and market development: the creation of new rules and reformulation of old ones to achieve the state's own goals. From the onset of China's economic reform in 1978, the Chinese rare earth industry has gone through three periods: the relaxation of central planning and industry development under state sponsorship (1978-1997), the expansion of domestic market and dominance in international trade accompanied with increased regulations (1998-2007), and the post-economic-crisis industry expansion accompanied with stronger state policies to steer its development (2008-present). Across different periods Beijing's development goals have not been static, but shifting objectives that sought to utilize and advance the strategic values of the rare earths relevant to the state. To achieve the industry development goals, Beijing has actively managed the industry's development through consistently introducing and adjusting industry-specific rules and policies. Yet contrary to the conventional wisdom of characterizing the PRC as a "strong state", the Chinese state capacity in reregulating this sector has in fact been limited. The author has found that both national-level and local-level independent variables have influenced the dependent variable, the state capacity to impose effective reregulation over the rare earth industry (the extent to which the industry's performance corresponded with the state's intended

goals and the policies and regulatory changes implemented by the state). At the national level, independent variables influencing state capacity include the State Council's bureaucratic authority systems over market actors, the local cadre management system, and the introduction and enforcement of specific property rights and criminal laws. Changes in these political and legal institutional variables have impacted the capacity of the state to impose effective reregulation campaigns across time. At the subnational level, local-level independent variables influencing the state capacity include the geographical concentration of local mineral deposits, the technology intensity of local mining production, and the local market concentration of mining licenses. Lower geographical concentration of local mineral deposits, lower technology intensity of local mining production, and lower concentration of mining licenses among local market actors lead to lower level of state capacity in South China compared to North China. The findings provide both theoretical and empirical contributions to scholarly debates regarding state-market relations and state capacity in China especially about its economic reform and globalization.

CHAPTER 1 INTRODUCTION

This thesis examines the role of the Chinese state in the development of China's rare earth sector. China's rare earth industry has rapidly grown since the late 1970s and become the leading global producer since the late 1990s, producing non-renewable mineral resources vital to the development of manufacturing industries and national defense. In recent years since 2008 China has implemented a series of new policies tightening the control over the production and trade of rare earth elements (REEs). Such policies have not only gained significant attention within the industry and the media, but they have also become a source of contention in China's trade relations with other major world powers. As the U.S. President Obama remarked[1], manufacturers all over the world "need to have access to rare earth materials which China supplies", and the threat that China's policies posed to the manufacturing of REE-enabled products is "too important for us to stand by and do nothing." (White House, 2012) Yet despite of the strategic and global significance of the rare earth sector both technically and policy wise, there has been very little research on the topic of the role of the Chinese state in the rare earth industry, even less from the political science perspective and through actual fieldwork. This interdisciplinary thesis fills this gap through analysis of in-depth stakeholder interviews, field site visits, and analysis of secondary data in China.

The author finds that instread of viewing the state intervention as a relatively new phenomenon in the rare earth industry, the Chinese central state has long engaged in "reregulation" in industry liberalization and market development: the creation of new

[1] The U.S. President Obama, On the WTO dispute jointly filed by the U.S., the E.U. and Japan against China over its rare earth trade practices, DS 431.

rules and reformulation of old ones to achieve the state's own goals. From the onset of China's economic reform in 1978, the Chinese rare earth industry has gone through three periods: the relaxation of central planning and the transition towards the market under state sponsorship (1978-1997), the expansion of domestic market and dominance in international trade accompanied with increased regulations (1998-2007), and the post-economic-crisis industry expansion accompanied with stronger state policies to steer its development (2008-present). Across different periods Beijing's development goals have not been static; shifting objectives in each period have sought to utilize and advance the strategic values of the rare earths relevant in the eyes of the Chinese state. To achieve the industry development goals, Beijing has actively "managed" the industry's development through consistently introducing and recalibrating industry-specific policies that assert the state as a prominent actor in both the expansion and the control of the industry. However, contrary to the conventional wisdom of characterizing the PRC as a "strong state", the Chinese state capacity of reregulation in this strategic industrial sector has in fact been limited. The author has found that both national-level and local-leval independent variables have influenced the dependent variable, the state capacity of reregulation (the extent to which the industry's performance corresponded with the state's intended goals and the policies implemented). At the national level, independent variables include the State Council's bureaucratic authority systems over market actors, the local cadre management system, and the introduction and enforcement of specific property rights and criminal laws. Changes in these political and legal institutional variables have impacted the capacity of the state to impose effective reregulation campaigns across time. At the subnational level, Beijing's reregulation has suffered more pushback from South China compared to North China. Local-level independent variables, including the geographic concentration of local mineral deposits, the technology intensity of local mining production, and the local market concentration of mining licenses lead to different levels of state capacity to steer local industry development to fit the state's goals in South China vs North China. The findings provide both theoretical and empirical contributions to scholarly debates regarding state-market relations and state capacity in China especially about its economic reform and globalization.

This introduction chapter includes an overview of the major research puzzle and theoretical framework, an introduction of the subject of the study (rare earth elements), a brief overview of the industry's development experience, the research design and research methodology, the policy significance of the study, and concludes with descriptions of each following chapter.

1.1 Theoretical Framework

At the core, this thesis studies the role of the state in industry development and the state capacity in fostering economic development. Classical paradigms in comparative politics includes the rational choice theory, modernization and development theory, cultural theory, world systems theory, and institutionalism, each offering different theoretical approaches to research puzzles. This thesis follows the paradigm of historical institutionalism. Historical institutionalists belong to the larger institutionalism paradigm which posits that institutions (informal and formal rules, policies and regulations) shape actor behavior, but they do not take the simplistic view that actor behavior and institutional changes arise from just rational calculations of costs and benefits. They take a historical, path-dependent view of institutions, actor behavior, and policy change. They build theories that emerge from "observed events or comparisons." (Hall & Taylor, 1996; Thelen, 1999)

1.1.1 Chinese State as the Reregulator in Industry Development

Using the case of the rare earth industry, this study is situated within a broad theoretical debate among scholars of Chinese political economy: *What is the role of the Chinese state in developing its industry and market expansion in the post-1978 economic reform?* Competing theories exist in understanding the state-market relations in China's post-1978 economic reform and marketization.[2] The "state decentralization" scholars argue that the Chinese state has achieved development through proactive privatization and decentralization, voluntarily retreating from the market. (Shue, 1995; Montinola, 1995; Oi, 1995; Qian, 1996; Qian, 1998; Oi, 1999; Blecher & Shue, 2001) The "state failure" scholars argue that the state has been a predatory state that has failed to effectively control the market actors and state bureaucrats. (Breslin, 1996; Yang & Wei, 1996; Zweig, 2002; Bernstein & Lü, 2003; So, 2007) The "state resurgence" scholars argue that the state has never relinquished control over the market, only the mechanisms of state control have been recalibrated in a reformed market economy. (Feigenbaum, 2003; Mertha, 2005; Zhang & Heller, 2007; Lin, 2008; Hsueh, 2011) The "state fragmentation" scholars argue that China's economic development has been instigated by competing political factions implementing competing agendas for marketization. (Lieberthal, 1992)

This study seeks to provide an empirical answer to the question. *What is the role of the Chinese state in industry development and market expansion of the Chinese rare*

[2] See Chapter 2 for a detailed literature review of competing theoretical perspectives on state-market relations in China's economic reform.

earth industry? This study argues that *the Chinese state has engaged in the reregulation of its rare earth industry*. To examine the role of the Chinese state, this study utilizes and expands the theoretical framework of “reregulation”. The traditional definition of reregulation in early literature as *increasing regulatory legislations over the market after deregulation in the advanced western liberal economies* (Weingast, 1981) does not apply here. This thesis adopts a more liberal interpretation of “reregulation” in recent literature: in market expansion and economic development the state actively *constructs new institutions and reforms old institutions* in order to *achieve the state’s own political goals*. (Vogel, 1996; Hsueh, 2011) In this regard, state reregulation in industry development may contain mechanisms which enhance market development and seemingly looked like “deregulation”, yet the state has never relinquished its control over the industry and market, only changed its method of control through introducing new rules and policies as well as adjusting existing rules and policies.

This study shows that the Chinese state has actively managed the industry’s liberalization and development process through consistently introducing and changing policies, rules and regulations. Such finding is largely in line with the view of the “state resurgence” theorists in that in the transition from the planned to the market economy, instead of voluntarily withdrawing from the market, the Chinese state has implemented policies to promote development to achieve its own goals and repeatedly strived to assert its influence over new market actors.

In arguing for the role of the state as the reregulator, this study examines both the state’s goals and policy changes in industry development. From the onset of China’s economic reform in 1978, the Chinese rare earth industry has gone through three periods of development, the state-led marketization (1978-1997), the state reregulation amidst global dominance (1998-2007) and the strengthened state reregulation (2008-present). The three periods correspond to larger macroeconomic changes of the Chinese economy, the transition from the plan towards the market (1978-1997), the expansion of domestic market and international trade (1998-2007), and the post-crisis development of market economy (2008-present). (See Figure 1) Across the three periods Beijing has consistently maintained that rare earths are “strategic resources” that warrant policy intervention. In fact, as Chapter 5 of this thesis shows, since the 1950s top leaders in Beijing have recognized the rare earth minerals as strategic resources valuable to the state. Yet “strategic minerals” is an imprecise term without a definitive interpretation. (Haglund, 1984) The “strategic” value of rare earths for China differs from the existing definitions of “strategic minerals” which largely focus on dependence on foreign import, substitutability/recyclability of minerals, and minerals’ importance to national defense[3]. This thesis examines the implied “strategic” value of the rare earth resources in the eyes of the Chinese state through studying the central leadership’s narratives and high-level objectives in each period. As Figure 1 shows, specific goals have guided the state in policy formulation in each period to utilize the maximize the strategic value of rare earths

[3] The International Strategic Minerals Inventory, a cooperative program of governments of the U.S., Canada, Germany, South Africa, Australia and the U.K., defined the term as “generally refers to mineral ores and derivative products that come largely or entirely from foreign sources, that are difficult to replace or substitute, and that are important to a nation's economy, in particular to its defense industry. In general, the term relates to a nation's perception of vulnerability to supply disruptions and to its concern to safeguard its industries from the disruptions of a possible loss of supplies.” (Jackson & Christiansen, 1993) The U.S. Strategic and Critical Minerals Stock Piling Act defines strategic and critical minerals as “those that (A) would be needed to supply the military, industrial, and essential civilian needs of the United States during a national emergency, and (B) are not found or produced in the United States in sufficient quantities to meet such need.”

in the eyes of the Chinese state at the time. From 1978 to 1997, the state's main goals were expanding rare earth production and export for obtaining foreign currency as well as advancing relationships with advanced western nations. From 1998 to 2007, the state's main goals were shifted to be promoting sustainable development and promoting indeginious innovation and value-added production. In the current period of reregulation since 2008, the state's main goals are promoting sustainable production, promoting technology upgrading to satisfy domestic demand, promoting technology upgrading to facilitate the development of downstream strategic and emerging industries, and breaking down the barrier to international market for domestic value-added production. These goals reflect a mix of political, economic and socioenvironmental concerns that together constitute the "strategic" value of rare earths in the eyes of the Chinese state. The study also examines the industry-specific policies and rules that the state has implemented and constantly adjusted in order to achieve its goals in each period. In each period the analysis includes industrial policies in several areas, including domestic production, export and foreign investment, technology upgrading, industry restructuring and environmental protection.

This thesis rejects an alternative argument of policy goals that could be attributed to the Chinese government, to punish foreign consumers of rare earths and use China's resource supply as leverage in international politics. Such a view was popularized after the extensive media coverage[4] of the alleged Chinese rare earth export halt to Japan in 2010 following the Diaoyu/Senkaku Island boat collision incident. Chapter 8 Section 4

[4] For instance, see (Bradsher, 2010a) for the New York Times article reported from Hong Kong and Tokyo that China had halted its rare earth export to Japan citing industry sources, and linked the halt with the ongoing Diaoyu/Senkaku Island incident and Japan's arrest of the Chinese captain.

specifically analyzes the allged embargo through studying the timeline of events related to Chinese export policies and Sino-Japan bilateral exchanges before, during and after the event, as well as analyzing the Japanese rare earth import statistics from China from the official Japanese Ministry of Commerce database. The author concludes that there is no concrete evidence for the alleged rare earth export embargo. Therefore, this alternative view of the state's objective is not supported.

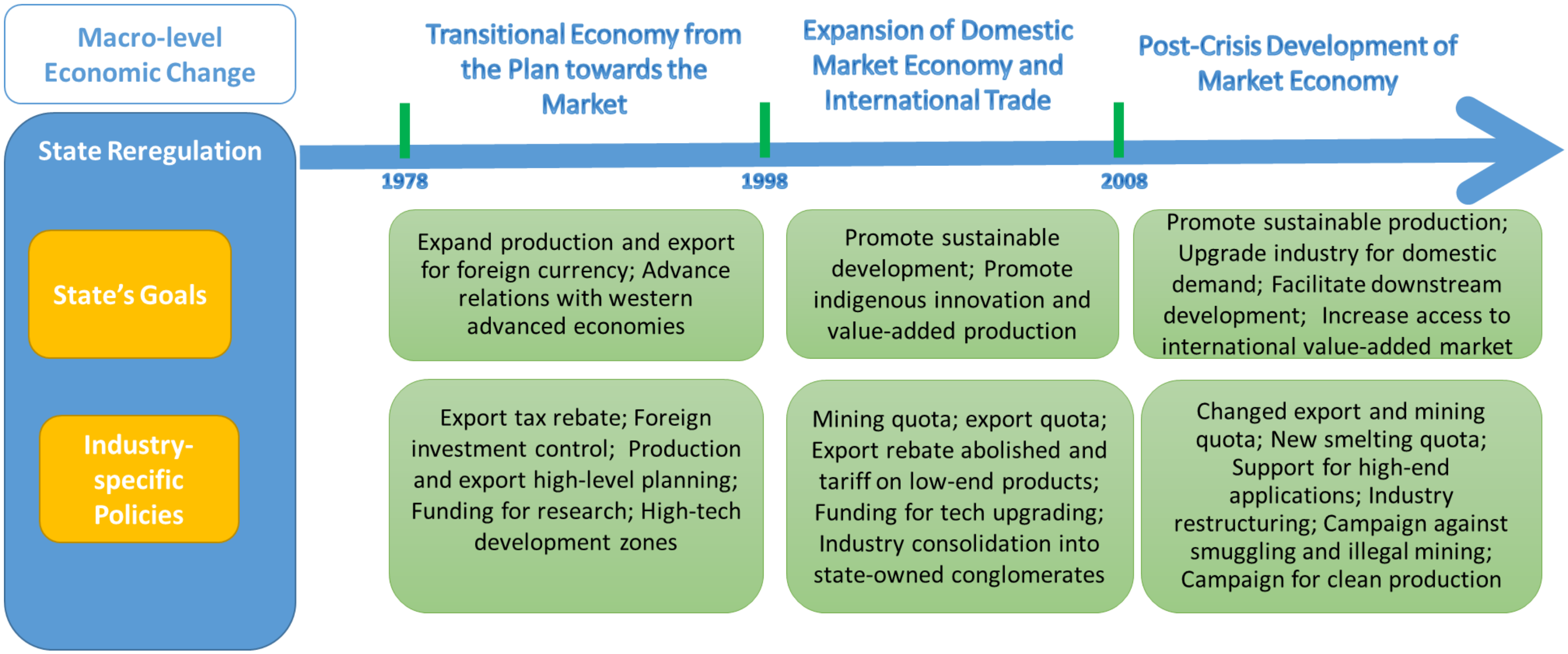

Figure 1 State Reregulation over Rare Earth Industry Development in Post-1978 Economic Reform

1.1.2 Determinants of State Capacity of Reregulation

How well has the Chinese state done in its reregulation of this strategic resource industry? The analysis in this thesis shows that compared with the state's intended goals, the industry development result has shown a mix of successes and failures in each period. Along with positive outcomes such as the drastic expansion of the rare earth production and sustained global market dominance, the Chinese rare earth industry has also been long plagued with issues contrary to the state's goals. Beijing's campaign-style policies were limited in their capacity to achieve the state's goals. Thus using the rare earth industry as the empirical case, this thesis also addresses the research question: *What factors influence the Chinese state capacity of reregulation over the rare earth industry?*

This thesis finds that *the Chinese state capacity in the reregulation of the rare earth industry is influenced by both national level independent variables (the State Council's bureaucratic authority systems over market actors, the local cadre management system, and the introduction and enforcement of specific property rights and criminal laws) and subnational level independent variables (the geographical concentration of local mineral deposits, the technological intensity of local mining production, the local market concentration of mining licenses)* (shown in Figure 2).

The dependent variable is the Chinese state capacity in rare earth industry reregulation, meaning the ability of the Chinese central government to achieve its own goals in rare earth industry reregulation. This thesis follows the classical definition of state capacity as the ability to "implement official goals, especially over the actual or potential opposition of powerful social groups or in the face of recalcitrant socioeconomic circumstances." (Skocpol, 1985) State capacity is analyzed as the extent to which the rare earth industry development outcomes correspond with the state's goals and policy targets in industry reregulation. The thesis assesses the development outcomes in four areas (industry production, international trade, market structure, and environmental and social impact) and compares the results with the state's original goals and policy targets.

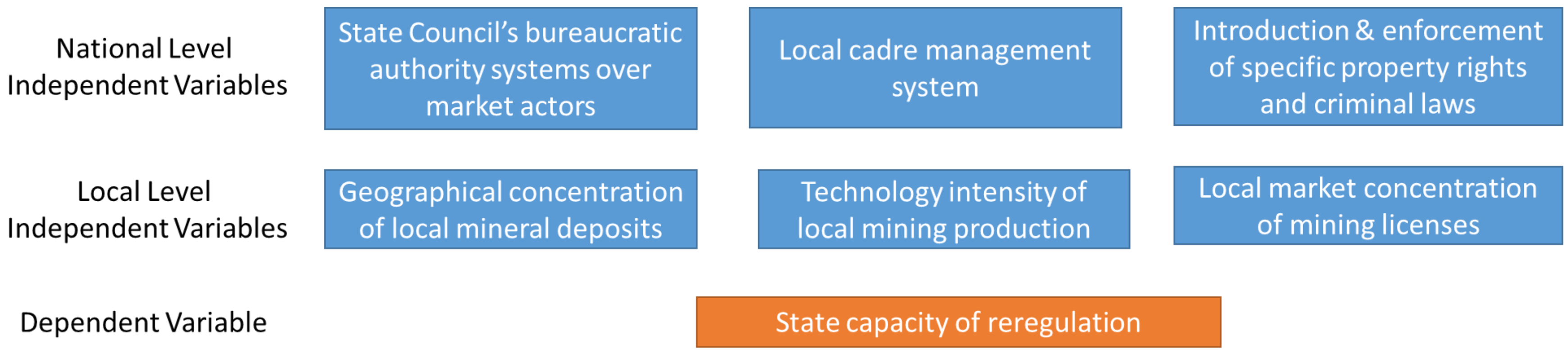

Figure 2 National Level and Subnational Level Independent Variables Influencing the Chinese State Capacity of Reregulation of the Rare Earth Industry

Using process tracing and comparison across different time periods, the thesis identifies national-level independent variables influencing the state capacity of reregulation. The changes in these national level political institutions have impacted the industry outcomes relative to the state's intended goals across time.

The State Council's bureaucratic authority systems over market actors refers to the the administrative institutions that Beijing has put in place to manage industry development and control the companies. The study analyzes the changes in the extent to which the central authority (the State Council) has administrative control over the state-owned companies and assets, the mining rights, and local industry projects. The study finds that successive State Council reforms have resulted in administrative changes in administrative systems, leading to decreased central capacity to coordinate policy making, and decreased central bureaucratic authority over state-owned assets and companies over time in comparison with the local governments. This led to weakened state capacity to control the local market actors and enforce its policies in the local regions. Yet Beijing has also actively sought to make up its deficiencies, as the trend of weakening bureaucratic authority saw some reversal in the current period of reregulation campaign since 2008.

The local cadre management system refers to Beijing's administrative system of managing local government cadres. The study analyzes the changes in the institutional features of local cadre management system, including the mechanisms through which the Communist Party appoints and removes cadres, the incentive structure for cadre evaluation and promotion, and the auditing and discipline inspection institutions to monitor and evaluate the performance of central ministries and local governments. The study finds that the lack of well-rounded criteria and the lack of sufficient independence from local influences in the local cadre management system have overall resulted in weakened state capacity to enforce its industrial policies. While Beijing has consistently introduced well-intended changes, more fundamental institutional changes would be necessary to reverse the incompetencies in the system that has weakened the state capacity to enforce its policies. From the 1980s until today, Beijing has introduced changes in the cadre management model, from "Two-Level Downward" model where the party authorities managed cadres at the next two lower levels, to "One Level Downward" model where the party authorities would only appoint and remove cadres at the next lower level, to "Dual Management" model that allows for dual control over the local cadres by both the local party committee and the higher-level ministry/bureau. The changes have resulted in zigzag shifts in the concentration of local cadres' decisionmaking power over key areas of the industry development. In terms of incentive structure in local cadre promotion, overreliance on economic growth figures has led to local cadres fixated on industry expansion at the expense of the state's other development goals such as sustainable production. In terms of the auditing and discipline inspection institutions which should serve as the last line of defense against local cadres' noncompliance with central policies, these institutions have suffered from the lack of administrative independence and transparency from the local bureaucracy, rendering the monitoring and evaluation of cadres hostage to local special interests.

The introduction and enforcement of specific property rights and criminal laws refers to the legal rules over property rights and prosecution of illegal activities. The study analyzes the changes in the legal rules and enforcement mechanisms of intellectual property rights (IPR) law and criminal laws that impacted the rare earth industry. The study finds that legal changes have had mixed effects on the state capacity to reregulate the rare earth industry. The introduction of clauses promoting technology transfer and the relaxed enforcement of IPR rules have allowed Chinese companies to practically circumvent some patent barriers in production, and inadvently facilitated the state-led industry expansion process but also created disincentives for investment in high-tech innovation. The miniscule criminal charges and the inefficient prosecution procedures have boosted local artisanal mining, and have also increased cadres and businesses' appetite for ignoring Beijing's mandates over production and trade.

While national level variables have directly impacted the state capacity to impose effective reregulation across time, local conditions have further contributed to how well Beijing's reregulation has been enacted across different regions. Specifically, in comparison with South China, the mining region in North China has higher geographical concentration of mineral deposits, higher technological intensity of production, and higher concentration of mining licenses. These subnational-level independent variables contribute to higher state capacity in implementing reregulation in North China.

Geographical Concentration of Local Mining Deposits refers to the extent to which the local mining deposits are concentrated geographically. In South China the local mineral deposits are spread out geographically in small-scale volume across many villages along the bordering regions of three provinces. In North China, the local mineral deposits are concentrated geographically in high volume within one mining district. The study finds that the lower geographical concentration of the mineral endowment in South

China leads to greater geographical dispersion of active mining sites across lower-level jurisdictions and less effective access for inspections, leading to less effective monitoring of state reregulation policies on the ground[5].

Technological Intensity of Local Mining Production describes the intensity of local technologies which are involved in the mining and processing of REEs. The study finds that lower technological intensity required in local upstream production of rare earth products in South China leads to lower barrier for market entry and more participation in artisanal mining, leading to higher chances of rule-breaking and less adherence to state rules.

Local Market Concentration of Mining Licenses concerns the structural characteristics of the local market in the control over mining licenses. China's rare earth industry has not had an established national or international trade exchange. Instead, the market operates through negotiated long-term contracts between ore suppliers, smelters, and downstream consumers. Thus primary ore suppliers with mining licenses control upstream supply. This study finds that lower concentration of mining licenses among local market actors in South China leads to greater difficulty in the negotiation of corporate mergers and acquisitions (necessary for Beijing's industry restructuring agenda to build conglomerates capable of abiding state mandates). This creates higher chances of local market actors in South China to protect their own market interests and ignore Beijing's agenda.

[5] This hypothesized relationship between geographical dispersion and power control is similar with existing literature concerning power projection in state building, such as Herbst (2000) which argued that sparsely settled population are great challenges to state power building. The difference is that this study is focusing on state capacity to control natural resources, whose geographical dispersion is to a significant degree determined by geological deposit conditions which cannot be changed by the state.

1.2 Research Design & Methodology

This study uses the approach of sectoral analysis frequently used in industry studies to study state policy strategies in enhancing economic competitiveness[6]. Sectoral analysis focuses on the specifics of the industry sector to study the variables leading the process of market change. This thesis sorts out the causal mechanism that explains the rare earth industry and trade development through process tracing, analyzing the historical patterns of development and structured comparisons within the sector. A longitudinal approach is taken to analyze the patterns of state reregulation, the political and institutional changes, and the corresponding effects on industry development at the national level. In analyzing subnational level variation in the effectiveness of reregulation, the author follows J.S. Mill's "Most Similar Systems Design" (Mill, 1843) using comparison between different geographical regions within the same sector under the same national policies, which allows for analysis of local variables leading to divergence in state capacity of reregulation.

This thesis employs data collected through a year-long field research in China and the United States. Data collection methods include semi-structured interviews, direct observation of industry production sites, and analysis of secondary sources (local archives, journals, newspapers and magazines, firm reports, and personal correspondence).

1.3 Rare Earth Elements as Critical Minerals

[6] Kitschelt (1991) compared the two approaches in studying state policy strategies to enhance industrial innovation competitiveness, sectoral analysis and cross-national comparative analysis. Kitschelt argues that the "traditional" approach of comparative analysis with sweeping aggregate comparison between national patterns can hide the variance of policies, governance structures and industrial innovation strategies between different industrial sectors.

Rare earth elements (REEs) are non-renewable non-ferrous mineral resources, consisting of a group of 17 chemical elements in the periodic table. (APS & MRS, 2011) This thesis follows the definition of “rare earth elements”, “heavy rare earth elements” (HREEs) and “light rare earth elements” (LREEs) by the American Physics Society and the Materials Research Society, two prominent global professional associations in physics and material science. REEs are used to produce essential materials for many high-tech industries crucial to economic development and national defense[7]. Their wide range of applications includes the permanent magnets (used in many modern technological products such as wind turbines and smart phones), lighting and displays (for instance LED lights and laptop screens), industry catalysts, and military technology applications (such as solid state lasers)[8].

Because of the important role that the REEs play in manufacturing, their secure supply has been recognized by governments worldwide as critical minerals:

1) United States: By 2011 the United States was “aside from a small amount of recycling 100% reliant on imports of REEs and highly dependent on many other minerals that support its economy”, according to U.S. Congressional Research Service specialist Marc Humphries[9]. (Humphries, 2011, p.2) Thus “in the case of REEs, the dominance of China as a single or dominant supplier of the raw material, downstream oxides, associated metals and alloys, may be a cause for concern because of China’s export restrictions and growing

[7] See APS & MRS (2011) for detailed analysis of the functions and industrial applications of each rare earth element.

[8] For a detailed analysis of the current demand of REEs by sector, see Chapter 4.

[9] Humphries has been writing annual updates on the rare earth industry supply chain and the U.S. policy response to China’s rare earth industry regulations.

internal demand for its REEs." (Humphries, 2011, p.2) The Department of Energy (2011) has determined five REEs (Dysprosium, Neodymium, Terbium, Europium and Yttrium) to be critical minerals for U.S. clean energy development and two other REEs (Cerium, Lanthanum) to be near-critical.

2) Japan: Because of its advanced industrial manufacturing, Japan has been a world leading consumer of non-ferrous metals, including the REEs. Japan relies 100% on import to meet its REE demand, among which 90% comes from China. (Kawamoto, 2008)

3) European Union: The European Commission published a list of 14 critical metals or groups of metals-with specific reference to the REEs- that are important for Europe's economy. (European Commission, 2014) The E.U. has also made the creation of a low-carbon clean energy economy to be a top policy priority. Two REEs, Dysprosium and Neodymium have been identified to be at high risk for imminent and future supply disruption for the E.U. low-carbon economy development. (Moss et al, 2011)

4) South Korea: All REEs are determined as rare strategic elements by South Korea in its Rare Metals Strategy, according to Taek Soo Kim, Director of Korea Institute for Rare Metals. Specifically, REEs are critical in two of the three Korean core industries, transportation system and energy/environment. (Kim, 2012)

China possesses the largest resource endowments of REEs in the world. The Baiyun-Ebo basternite deposit in Baotou, Inner Mongolia in North China is the world's largest REE deposit and current production source, containing primarily LREEs. The ion-adsorption clay deposits in Gannan-Yuebei region bordering Guangdong Province, Jiangxi Province, and Fujian Province in South China is the second largest production source of REEs in terms of production amount, and the world's only active HREE production source.

1.4 A Primer on China's Reregulation of Rare Earths

China's rare earth sector is among the few natural resource sectors in that country that has achieved an almost complete dominance in the global market. The sector is a "small industry with large impact"[10]. As a very small industry within China's gigantic economy (it accounts for less than 1% of the national GDP[11]), the industry produces materials used in many downstream industries. From 2002 until 2013 China had been the only major producer in the global market, producing between 95%-97% of all REEs in the world (and more than 99% of the output for two of these elements, dysprosium and terbium, vital for a wide range of clean energy technologies). Due to modest progress in seeking alternative materials and engineering designs, as well as the expected strong growth in REE demand from the rapid growth of new industries such as clean energy[12],

[10] Remark by Hong Feng, former director of the State Rare Earth Office at the 2014 Rare Earth Expert Forum hosted by the Ruidow Metals in China.

[11] See Yang (2013) for an overview of China's rare earth industry. Yang is the Director of the Industrial Resource and Environment Office at the Institute of Industrial Economics at the Chinese Academy of Social Sciences.

[12] James Hedrick (2010), a former USGS analyst with specialization on rare metals, argued that U.S. supply of rare earths in the short term will come from China; growth in the demand of rare earths in the long term is expected to be substantial as new applications and discoveries are made. Hedrick also found that only a few rare earths applications will be substituted. Alonso et al. (2012) has found that without efficient reuse or recycling of rare earths, or the development of technologies reducing the use of Dysprosium and Neodymium, following a path consistent with stabilization of atmospheric CO_2 at 450 ppm may lead to an increase of more than 700% and 2600% for the two elements respectively over the next 25 years if the present REE needs in automotive and wind applications are representative of future needs.

China is expected to continue its dominance in the global supply chain for some time to come[13].

1.4.1 State-Sponsored Industry Development under the Planned Economy in 1950-1997

Rare earth deposits were first found in China in 1927, but exploration of deposits did not take place until the 1950s, after the Communist Party won the revolution and founded the People's Republic of China in 1949. (Chinese Academy of Sciences, 2009) The strategic value of REEs was recognized by scientists and the Communist leaders in the newly founded People's Republic China (PRC). Initial mining exploration and technology development began in the 1950s with support from the Soviet Union. (Zhang, 2012) Chinese scientists and engineers petitioned the authority to begin exploration and extraction of rare earths in the Baiyun-Ebo region in Baotou, Inner Mongolia, despite of opposing opinions from the Soviet scientists who concluded that the rare earth deposit which coexisted with majority iron deposit was not worthy of exploration. (Yap, 2011) Mr. Nie Rongzhen, a senior leader in charge of China's defense technology development, championed the development of indigenous rare earth production technologies. (Nie, 1999) In accordance with the practice of establishing large-scale military-industrial programs for developing science and technology, the central government established research institutes and defense factories across China to develop China's rare earth production chain.

The state's control over the industry and the science community was a double-edge sword: anti-intelligentsia campaigns waged by the state, especially the Cultural

[13] See Chapter 4 for extended analysis on the global rare earth supply.

Revolution (1966-1976) led to state's estranged relationship with the science community and paralyzed the nation politically and economically[14]. While political turmoil displaced most of China's institutions and industrial capacity in the Cultural Revolution era, the rare earth industry received state protection and priority allocation of resources as part of the military-industrial complex[15]. In 1975, an inter-ministry group called "National Rare Earth Applications Promotion Leadership Group" was established in Beijing and became the direct national administrative body overseeing the industry development.

1.4.2 State-led Marketization of the Industry and Trade Growth in 1978-1997

As China embarked on its economic transition from planned economy to market economy and global integration in 1978[16], its rare earth industry enjoyed significant growth. The rare earth industry was blessed with strong continuous support from the state, while the focus shifted from its defense utility in the Mao era to civilian applications in the reform era. In the earliest years of the reform, the central government saw the export of rare metals as both economically beneficial to finance China's industrial modernization, and also "an important means of cementing China's strategic ties with the West." (Park, 1981) The Communist Party leader Deng Xiaoping made the famous remark in 1992 that "There is oil in the Middle East; there is rare earth in China." (Baotou Rare-Earth Hi-Tech Industrial Development Zone, n.d.) The central government

[14] See Chapter 5 for detailed analysis of the influence of political campaigns on the science and technology development.
[15] See Chapter 5 for detailed analysis of the preferential state treatment for rare earth industry and the technical progress of the industry in the Cultural Revolution era.
[16] The Chinese Communist Party leader Mr. Deng Xiaoping began implementing the "Reform and Opening" policies in 1977, beginning the transition of Chinese economy from the plan to the market and the integration of the Chinese economy with the world.

narratives of development featured both marketization (promoting industry growth and market expansion) and regulation (keeping the industry development under state control).

The state strived to achieve global dominance through policies promoting export and production expansion; at the same time, the state also vowed to keep the booming industry under state regulation through consistently introducing and changing rules, and not let the market play the invisible hand. In other words, the industry liberalization reform was accompanied not with the state voluntarily exiting the market with less rules, but with the state actively asserting itself in the market with more and changing rules. The State Rare Earth Leadership Group, an inter-agency group reporting to the State Council, oversaw the formulation and execution of national development strategy for rare earth industry. (Su, 2009) In promoting export, the state acted as a strong broker and supporter for firms trading with western consumers, and it maintained international competitiveness through providing export rebate and upgrading industrial technologies. The central government mandated in 1987 that rare earth products could only be exported by three state-owned trading groups, and in 1990 it introduced export control for ten categories of rare earth primary products. (PRC Ministry of Foreign Economy and Trade & State Economic Commission, 1987; PRC State Council Rare Earth Leadership Group, 1990) In production, the state put the ion-adsorption rare earth deposits (mainly in South China containing high-valued heavy rare earth elements) "under state planning" and required mining and smelting licenses approved by the central government in 1991. (PRC State Council, 1991) The state banned foreign investment in mining ion-adsorption rare earth ores in 1990 (PRC State Council Rare Earth Leadership Group et al, 1990) and limited foreign investment in rare earth smelting in 1995. (PRC State Planning Commission, 1995)

Several national-level political and legal institutional factors in this period influenced the state capacity to implement its control measures, and they contributed to the rapid and increasingly localized growth of Chinese rare earth production and export. Firstly, changes in the national bureaucratic authority systems governing the market actors showed a stronger shift in administrative control from Beijing towards the local authorities. In enterprise management, the central state-owned enterprise groups that became major players of the rare earth industry showed a considerable degree of overlapping administrative control over day-to-day management between the central and local authorities. In decision making, the devolution of bureaucratic authority over economic affairs within the administrative hierarchy led to significant increase in new mining and smelting projects. Secondly, in terms of the bureaucratic system managing party cadres, successive changes weakened the center's bureaucratic control over the local cadres. The cadre promotion system saw a delegation of authority as the state switched from "Two Level Downward" to "One Level Downward" model. The state later switched to "Dual Management" model to mitigate local corruption and nepotism, yet local cadre promotion in key areas of governance relevant to the rare earth industry still remained largely in the power of the local government. A GDP-fixated promotion system further prompted local cadre to promote rare earth businesses as a way to both support local economy and government revenues, and to gain political capital for personal career. The auditing and discipline inspection institutions were largely incapable of monitoring cadre behavior. Finally, in terms of laws and law enforcement over property rights, China's intellectual property rights law only introduced in 1985 and China's subsequently relaxed enforcement allowed technologies to be transferred freely across regions and between companies and state-affiliated research institutes. Certain clauses in the intellectual property rights law also inadvendently allowed Chinese producers to bypass patent barrier from foreign competitors in the Chinese market. This led to low technology barrier for both market entry into the international and domestic market.

The result of the state-led industry marketization was a rapid growth in rare earth production and export. China managed to overtake the other countries in the global market in less than two decades. From 1983[17] to 1988 the annual production of REE products in China grew tenfold in merely five years (from about 3000 tons in 1983 to 30000 tons in 1988). By 1988, China had emerged as the world's largest rare earth smelter after Japan; its output surpassed the U.S., the primary global producer before China's rise in the global market. By 1997, Chinese companies dominated the global market for rare earth primary products. Yet rapid growth came with significant growing pain, including low value-added production and export, unhealthy competition between a large number of small-scale producers, and poor record of environmental protection.

1.4.3 State Reregulation under Deepening Economic Reform in 1998-2007

In the ten-year period between 1998 and 2007, the central government continued the economic reform, promoting the marketization of China's SOEs and innovation from S&T institutions, as well as greatly expanding China's participation in international trade. As China became the de facto global supplier of REEs, the state's goals for reregulating the industry shifted away from primarily expanding industry production and market

[17] China's export and production of rare earths started occurring in large volumes in 1983.

growth towards creating higher value and sustainable return from the extraction and utilization of the strategic resource. In particular, two goals were evident: promoting sustainable development through curbing production capacity and environmental pollution, promoting industry upgrading through fostering indigenous innovation and value-added production.

The central government, continuing its role as the reregulator to proactively guide and control industry development, enacted various policy changes to the industry. The state imposed production, trade and investment restrictions over low-end production and regulations favoring value-added production and export, and provided direct institutional support and financial grants for upgrading production and promoting indigenous innovation in domestic rare earth companies. In export, the state abolished export tax rebate in 2005 and began to introduce export tariff on various low-end rare earth products[18]. In foreign investment, the state banned foreign companies from investing in rare earth smelting in 2002. (PRC National Development and Planning Commission, 2002) The state further banned all foreign-domestic joint investments from mining in 2006. (PRC National Development and Planning Commission & Ministry of Commerce, 2006) In mining production, the Ministry of Land and Resources temporarily withheld all mining license applications several times and started issuing mining quota for rare earth concentrates in 2006. (PRC Ministry of Land and Resources, 2010) The state attempted to achieve direct control over the already localized industry growth through consolidating the entire industry into two state-owned conglomerates, but it gave up the plan by 2005. (PRC State Economic and Trade Commission et al, 2002; Dai, 2005)

[18] See Chapter 5 Section 3 for changes in export tariffs between 2007 and 2015.

The result of state reregulation was influenced by broader changes in China's political and legal institutions. Firstly, in terms of the State Council's bureaucratic control over the market actors, successive bureaucratic reforms resulted in weakened central bureaucratic authority governing the companies in the rare earth industry. After two State Council reforms and subsequent bureaucratic infights, former central enterprise groups were split apart, resulting in the transfer of authority relations, state assets, and mining licenses to the local governments and local SOEs. Central SOEs were greatly weakened in their control over the market, and they understandably lost in their attempt to spearhead national consolidation. The bureaucratic changes also resulted in the devaluation of the State Rare Earth Office from an inter-ministry unit to an office below the ministry level, resulting in the lack of policy coordination between ministries over the industry and regulatory loopholes for producers to evade regulation. Secondly, in terms of the local cadre management system, the state implemented some well-intended changes emphasizing social responsibility, but it did not fundamentally change the primary emphasis on economic growth in cadre promotion. The small changes to the discipline inspection institutions also did not solve the inherent institutional conflict in monitoring and evaluating local cadres while inspectors could not gain independence from the administrative control of local governments. Thus the local cadres were still motivated to promote local rare earth businesses and pocket their own shares, not to promote development in an equitable or sustainable way. Thirdly, in terms of criminal law and law enforcement, prosecution of activities deemed illegal under the new laws and regulations were inefficient and suffered from the lack of cross-jurisdiction coordination, contributing to the lack of enforcement of central government policies in local regions.

The Chinese rare earth industry was sustaining its predominance in global market supply in this period. On the bright side, the industry achieved massive success in expanding its value-added production, upgrading itself from just providing upstream supply to more mid-stream products. Yet the industry was also fraught with problems contrary to the state reregulation goals and policy targets, including excessive mining and smelting production capacity, prevalent extra-quota mining production and illegal smuggling, poor industry profit margins, and worsening environmental degradation.

1.4.4 Strengthened State Reregulation Tightening the Control over the Industry Since 2008

The global financial crisis in 2008 left the global economy in deep distress, including the global rare earth market. The current state reregulation is driven by multiple goals that pertain to both the existing issues/problems in the rare earth industry and the new post-crisis economic environment. The state wanted to satisfy the growing domestic consumption demand under the post-crisis stimulus plan. The state wanted to further its technology upgrading and develop high-tech emerging and strategic industries in the further downstream. The state wanted to curb rampant environmental pollution and change the unsustainable model of development. The state wanted to secure greater advantage in the development of applications and downstream production and not be subject to patent constraints to international markets.

The Chinese central government vowed to strengthen centralized control over the rare earth industry by implementing a series of policy initiatives. The central government has so far introduced rules and initiatives over export and production planning, market consolidation and market entry, anti-smuggling, industry upgrading, and pollution control.

1) Export restriction: The state reformed the export quota and tariff system, and continued control over primary ore production. Export quota issued by MOFCOM (Ministry of Commerce) significantly declined in 2010, and for the first time the export quota was not able to accommodate actual export volume[19]. The export quota authorized fewer exporters, separated between different categories of rare earth products with varying values, and made exporter licensing contingent upon meeting environmental standards. The tariff system was also reformed, with increased export tax on lower-end products and export rebates only on high-end products[20]. The export restrictions received strong international complaints. The WTO ruled against China's restriction over rare earth export in 2014. China abolish its export quota in January 2015 (PRC Ministry of Commerce, 2014) and tariff in May 2015. Yet China immediately implemented a similar-level new resource tax on both export and domestic production. (PRC Ministry of Finance, 2015; PRC Ministry of Finance & State Administration of Taxation, 2015)

2) Mining and production restriction and taxation: The Ministry of Industry and Information Technology started to issue quota for rare earth products in 2008. The Ministry of Land and Resources (MLR) continued to issue "quota for mining rare earth ores" (稀土开采指标) to control the production, and put licensing of new mining projects on hiatus. (PRC Ministry of Land and Resources, 2014) Immediately after China scraped its export quota and tariff to comply with WTO ruling, the State Administration of Taxation introduced gross-sales-based resource tax of 7.5%-11.5% on light rare earth ores and primary products and as much as 27% resource tax on the more valuable heavy

[19] See Chapter 8 for calculation of previous years' export quota and export volumes based on MOFCOM data.
[20] See Chapter 8 for calculation of changes in export tariff for various kinds of rare earth products.

rare earth ores and primary products. (PRC Ministry of Finance & State Administration of Taxation, 2015)

3) Promotion of industry upgrading: The state has introduced new initiatives promoting basic and applied research, increasing value-added production, and development of high-end applications. These measures include allocating funding totaling 350 million RMB for REE-related research projects in the 12th Five-Year Plan (2011-2015) (Li, 2011), allocating special funds for R&D and commercialization of high-end REE application projects (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2012), and downsizing production capacity of firms using "backward" technologies. (PRC Ministry of Industry and Information Technology, 2014)

4) Industry consolidation into state-owned conglomerates: The state released again an ambitious plan of creating state-owned conglomerates amassing at least 80% of national production capacity by 2012. (PRC State Council, 2011) Yet amidst the intense bargaining and contentions between central government, local governments and producers, the consolidation has dragged far behind its original deadline. By 2015 the state selected 6 central-government-controlled and local-government controlled firms to establish major rare earth groups, and the MIIT began to directly issue production planning quota to each of the six firms. (PRC Ministry of Industry and Information Technology, 2015) Coupled with industry restructuring into state-owned conglomerates, the state implemented new policies eliminating small local producers. These regulations include prioritizing production and export quota for large firms, more stringent licensing and environmental compliance requirements for production and export (PRC Ministry of Environmental Protection, 2009), higher standard for licensing of new projects, and

higher market entry criterion based on production capacity and prior years' production performance. (PRC Ministry of Industry and Information Technology, 2012)

5) Campaign against smuggling and illegal mining: Beijing has also enacted new rules to curb smuggling and out-of-plan production. These include providing bonus to the public for reporting illegal activities[21], implementing successive special inspections by inter-ministry working groups of the central government (PRC Ministry of Industry and Information Technology et al, 2011; PRC Ministry of Industry and Information Technology et al, 2013; PRC Ministry of Industry and Information Technology et al, 2014), binding the tenure of local government officials with "no illegal activities within their jurisdictions"[22], implementing special invoice system tracking rare earth product transactions (PRC State Administration of Taxation, 2012), and providing funding for local governments to install infrastructure necessary for survelliance and inspections. (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2012) According to the Ministry of Industry and Information Technology (MIIT), 55 illegal rare earth producers and 22 illegal mines were shut down between 2011 and 2015. (Chang & Hui, 2015) However, illegal production still permeates the industry. MIIT estimates that from September 2014 to May 2015 alone about 12,400 tons of rare earths were mined illegally in China. (Chang & Hui, 2015)

6) Campaign for clean production and pollution treatment: Apart from regular environmental inspections, the central government has introduced special

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[21] The quasi-government industry association "Association of China Rare Earth Industry" (ACREI) provides one-time bonus of 50,000 RMB to the public for reporting illegal activities in the industry. See http://www.ac-rei.org.cn/portal.php?mod=view&aid=2003 for the announcement of the bonus and the procedure for reporting illegal activities.

[22] Author interview with a county government official in Ganzhou, Jiangxi Province in July 2013.

initiatives including allocating special funds to firms for treating pollution and allocating bonus funds for firms compliant with environmental inspection (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2012), implementing industry-specific emission guidelines (PRC Ministry of Environmental Protection, 2009) and standards of clean production (PRC National Development and Reform Commission et al, 2015), and making environmental compliance the requirement for allocating production plans (PRC Ministry of Industry and Information Technology, 2012) and export quota. (PRC Ministry of Commerce, 2011) It would however take significant amount of money and many years to treat the existing environmental pollution that are consequences of decades of production[23].

Political institution factors at the national level still influence Beijing's effectiveness in the current campaign over the industry. Firstly, in terms of the State Council's bureaucratic authority over the market actors, the State Council has implemented some good changes increasing inter-ministry cooperation to increase its capacity to coordinate ministerial policies concerning the rare earth market. Secondly, in terms of local party cadre management, Beijing has introduced changes to cadre promotion and evaluation strengthening the power of discipline inspectors and the emphasis on non-economic targets for promotion. However, specific local agencies such as environmental protection bureaus have still been often unable to enforce central policies independent of the influence of local governments. Thirdly, in terms of law enforcement, Beijng has put forward new mechanisms of cross-jurisdiction government

[23] Take the pollution in Ganzhou, a major mining region in South China as an example. According to a State Council report, treating more than 1.9 tons of solid waste would take 70 years. (Liu & Liu, 2012) The Minister of MIIT estimates that treating existing pollution in Ganzhou would require total of 38 billion RMB funding. (Yang, 2012)

cooperation in enforcing laws and regulations concerning the rare earth industry. However, lack of effective legal clauses in the current Criminal Law to persecute noncompliant behavior, as well as the low legal penalty for breaking the rules still created great incentive for market actors to evade Beijing's restrictions. Thus more institutional changes are still needed if Beijing wants to strengthen its capacity to implement the new rules.

The current reregulation campaign shows a mix of successes and failures. In terms of industry production, Beijing's efforts to control production volume through smelting production plan has been not so successful, as smelting production has been higher than the plan. Furthermore, instead of leading to a more stable market conducive to long-term growth, Beijing's policy campaigns prompted drastic market price changes in 2010-2013, with domestic prices peaking in mid-2011 for the different kinds of rare earth oxides at prices roughly 7-20 times of pre-2010 levels. The price shock not only led to market speculation and instability, it also affected downstream production to the point of inducing bankruptcies. In terms of technology upgrading, China's rare earth consumption by the new materials sectors has shown a strong increase compared to the relatively flat consumption by traditional sectors, showing a continued strong trend towards upgrading the value chain. In export, China's export volume has stayed below its export quota since 2011, before it was required to scrap the quota and tariff restrictions to comply with WTO ruling in 2015. China's export of higher-value rare earth products have continued to increase, yet many domestic permanent magnet producers have still been locked in a patent-induced market entry battle with Hitachi. METI's export control on high-value permanent magnets also led to delays in planned Sino-Japan joint ventures producing higher-value permanent magnets in China. In terms of the market structure, Beijing's original plan to restructure the industry into 2-3 conglomerates in two years has dragged behind the timeline and suffered significant local pushback. The restructuring process has become a gruesome battle amongst central SOEs, local SOEs, and local private companies for survival and the chance to become Beijing's pick. By 2015, two central SOEs and four local SOEs were selected into the MIIT's tentative list of corporations allowed to receive production quota. In terms of environmental protection, Beijing's funding schemes and institutional rewards have resulted in new and larger initiatives by companies and local governments to treat existing pollution and upgrading technologies of production. Yet the pollution legacy is so gigantic that it is impossible to achieve much progress in ecological restoration in the short term.

1.5 Significance & Policy Relevance

China's reregulation on rare earth production and export has garnered significant worldwide attention. As a group of critical materials, REEs contribute to the development of high-tech consumer industries and defense technologies, critical to the technological and infrastructural base of global economies. The capacity of the Chinese state to impose its political objectives of reregulation of rare earth production and trade will influence the end users of manufacturing companies across the world. The 2012-14 WTO case launched by the U.S., E.U. and Japan against China over its rare earth practices is an example[24]. This study contributes empirically to the policy discussions on this particular strategic industry that has not been studied extensively before.

[24] The U.S., Japan and the E.U. have jointly filed in 2012 and won the WTO lawsuit in 2014 against China, which rules that China must change its restrictive practices in rare earth export. In response, China eliminated rare earth export quota and tariff in April

Besides the apparent practical significance of studying China's rare earth policies and policy outcomes, this study also contributes to the broader discussion on the "rise of China" in the 21st century. In recent years, scholars have set out to explain the implications of the rise of China as an economic power for the international system. China's de facto monopoly in producing this group of strategic minerals from the late 1990s until 2013 was seen by many as evidence of China's rise in global economy and using its economic advantage to advance its international power ranking. This study shows perhaps paradoxically, the not so rosy picture of domestic governance issues accompanying China's rise: throughout the marketization and development process of a key industry that has achieved significant growth and trade expansion, Chinese central government has yet to achieve its desired extent of market control. At the national level, institutional factors impede effectiveness of the state reregulation. At the sub-national level, market, geographical and technological factors constrain the state's capacity of imposing effective reregulation over the localities. How to turn its resource superiority into political power on the world stage, as this study shows, remains a mighty challenge to the Chinese government.

1.6 Organization of the Study

This thesis is organized into ten chapters. The following nine chapters are summarized as follows:

Chapter 2 presents an overview of the recent sets of literature relevant to this research, grounding this study in key theoretical debates. This literature review includes the literature on the state-market relations in industry development and in transitional

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2015, but introduced a similar level of resource tax on both rare earth domestic production and export. See Chapter 8 for more details.

economies such as China, the literature on the state capacity to foster industry development, and the literature on China's rare earth industry development.

Chapter 3 delineates the research design and methodology of this study.

Chapter 4 presents the analysis on the science and technology aspect of the rare earth industry production, market supply and demand, and the global rare earth industry value chain. This sets the stage for analysis of the rare earth industry in China in the following chapters.

Chapter 5 analyzes the industry development under state planned economy from the founding of the People's Republic of China in 1949 to the late 1970s. Prior to the start of the economic reform in 1978, the state recognized the value of rare earths as critical minerals and built up the foundational capacity for rare earth industry development. This chapter serves as the background to explain the path of the rare earth industry development and the key state institutions involved in industry development preceding the start of China's economic reform and global trade integration in 1978.

Chapter 6 examines the state-led industry liberalization and trade development in 1978-1997. The state's objectives on rare earth industry development shifted from its defense utility to its economic utility as resources for export. In the process of industry liberalization, the state introduced more rules and made frequent adjustment to the new rules on industry production and trade. With strong state support, the rare earth industry achieved significant market and industry growth and was on track to dominate global production. National-level changes in political and legal institutions had mixed impacts on the outcome of the extent to which the state goals and policies were realized.

Chapter 7 examines the state reregulation over the rare earth industry in 1998-2007. This ten-year period saw China undergoing deepening economic reform and privatization of the SOEs and S&T institutions. The state sought to maintain its global competitiveness in rare earth trade and production while maximizing the critical, long-term value of rare earths. Motivated by changing development goals, the state introduced new industrial policies and made policy changes to actively control the trajectory of development. At the same time, national-level changes in political institutions affect the extent that the state was able to enact its new control measures.

Chapter 8 studies the current reregulation campaign featuring more restrictive and forceful policies over the rare earth industry since 2008. China sought to advance its economy to sustain its global competitiveness after the financial crisis. The state introduced new development goals, industry-specific measures to wage a campaign for stronger governance. The state sought to make adjustments to the political and legal institutional features inhibiting policy implementation, yet the changes were not enough. The policy changes implemented in the style of drastic and swift campaigns also created inadvendently strong market uncertainties and created discontented losers in the market.

Chapter 9 discusses the regional disparity in Beijing's record enforcing the current post-2008 reregulation. This chapter examinines the geographical, technical and and market features of the two subnational mining regions that led to differences in the state capacity to effectively implement its policies to achieve the state's goals.

Chapter 10 contains the conclusions and policy recommendations.

CHAPTER 2 LITERATURE REVIEW

This case study on a strategic natural resource industry in China aspires to contribute theoretically to three strands of literature concerning the role and capacity of the state in developing the economy. The first strand of literature concerns the debate on state-market relations in economic development and market expansion. Particularly concerning literature on the state-market relations in China’s post-1978 economic reform and marketization, this thesis empirically tests competing theories on the role of the state: whether as an active proponent of privatization and decentralization, or as an involuntary failure of imposing control, or as an active defender of control over the market actors, or as a fragmented bureaucracy with competing marketization agendas. The second strand of literature concerns the broad notion of state capacity, the state capacity specifically in fostering economic development, and the determinants of the state capacity in implementing state goals. The third strand of literature concerns empirical research on the rare earth sector in China, and this thesis provides empirical contribution to this growing body of literature. This thesis found that the Chinese state has engaged in active “reregulation”, leading market expansion and liberalization while implementing new rules and institutions to serve its changing political goals that were concerned with preserving and utilizing the strategic value of the rare earths in differen time periods. However, the Chinese central government faces significant challenges to achieve the desired control over the market. This thesis further suggests that the state capacity to assert its political objectives over the rare earth industry is influenced by institutional factors at the national level and local contextual factors at the sub-national level.

2.1 Literature on State-market Relations

Scholars studying economic development have now increasingly paid great attention to the complex relationships and linkages between the state, the market actors and the social structure in a given country. Such trend can be attributed to the growing pressure for the states now to engage in both domestic economic reform and global economic engagement as a result of the increasingly globalized industrial production. This section provides a review of literature on the debate concerning state-market relations in market development, and on the contrasting theoretical lenses of studying the state-market relations in the development of China's transitional economy.

2.1.1 Debate on State-Market Relations

Debates on the state-market relations in economic development can be traced back to competing assessments in classical theoretical approaches to political economy. On the one hand, scholars of mercantilism, a dominating economic ideology in the western European economic theories and policies from the 16th to the late 18th century, argued that the states ought to implement interventionist policies to protect the interests of the merchants and producers in international trade and to ultimately empower the states themselves[25]. As Anderson (1976, p.36) states, "Mercantilism was precisely a theory of the coherent intervention of the political state into the workings of the economy,

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[25] It should be emphasized that mercantilist scholars argue that this approach is not a theory of how the market economy is supposed to operate, but a pragmatic adaptation of the reality of economic practice. The idea that the state uses its authority to aid the development of capitalist is central to the mercantilism approach. For an overview of the approach of mercantilism and its relevance to the development of modern European states, see Heckscher, 1934. According to Woo-Cumings et al. (1999), the intellectual foundations of the East Asian developmental state model can be traced back to mercantilism.

in the joint interests of the prosperity of the one and the power of the other." On the other hand, scholars of classical liberalism[26] argue that *Laissez faire* is the better economic approach, and any government intervention in market expansion and industrial development is harmful. The intellectual roots can be traced back to Adam Smith's *The Wealth of Nations* (1887), which argues that the pursuit of self-interest which is inherently human nature drives the maximization of wealth. The market acts as an "invisible hand" directing the actions of individuals and firms to maximize their own gains and allocating the resources and opportunities most efficiently.

2.1.1.1 The East Asian Developmental State Model

For scholars of East Asia, the discussion on state-market relations has been heavily influenced by the model of the "developmental state", which posits that the state manages and leads economic growth and social change[27]. Johnson (1982), one of the most prominent scholars of East Asian Newly Industrialized Countries (NICs) is often credited as the developer of the "developmental state" model. Johnson argues that the Japanese economic bureaucracy, particularly the Ministry of International Trade and Industry (MITI) has been instrumental in forming the "plan-rational state". Through rational planning, MITI created interests in the Japanese economy which favors resource allocation in its target industries. Scholars employing the developmental state model generally argue that developmental states place industrial policy as the highest policy priority. The state facilitates and even directly guides economic development relying on its professional public servants. The ideal state needs to have an efficient, loyal, rational

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[26] Classical liberalism emerged in the late 18th century and achieved prominence in the 19th and early 20th centuries. For an overview of the classical liberalism's view on state-market relations in market and industry development, see Sally (2002).
[27] For an overview of the developmental state model, see Woo-Cumings, 1999.

Weberian bureaucracy[28] that is committed to implementing policies formulated by the political elite and prioritizes long-term development goals over short-term economic gains.

Thus a central feature of the "developmental state" is a high degree of state capacity[29]: to extract resources and appropriate resources in ways determined by the political elites, to regulate the relationship between market and social actors, and to resist demand from market actors or social groups from getting in the way of state policies. With respect to formulating and implementing economic policies, in order to uphold a high level of state capacity in economic development, scholars following the developmental state model have argued that the state needs to have a certain degree of autonomy to resist pressure from particularistic interests.

2.1.1.2 From State-Centric to State-Market/Society Framework

Recent scholars have departed from this early characterization of the developmental state as merely autonomous state with professional meritocratic bureaucrats imposing policies on the industries and preventing demand of social groups from thwarting policies formulated by the political elite. These scholars see the original developmental state model as too simple, state-centric and over-generalizing the process of policy formulation and implementation. For instance, Wade (1990) challenged claims both of neoliberalists, who saw the East Asian economic development as a vindication of free-market growth, and of the hard-core state-centric theorists, who attribute the growth only to strong state

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[28] For instance, Rauch and Evans (2000) found that "Weberian" state bureaucratic structures lead to increased economic growth.

[29] The "developmental state" school's understanding of strong capacity is in line with Migdal (1988), who argues that a state with high capacity must be able to complete four tasks: to penetrate society, to regulate social relationships, to extract resources, and to appropriate resources in determined ways.

intervention. While he still largely agreed with Johnson's interpretation of East Asian success as state-led growth, Wade argues that the way allocation decisions were divided between the market actors and the bureaucracy and the synergy between the state and the market were critical to explain the state's capability to foster economic growth.

More recent scholars studying industrial growth have called for analyzing the "embeddedness" as well as the "autonomy" of the state. Contrary to traditional views of the developmental state model which sees lobbying and other forms of informal state-market interactions as diminishing the "strong" state, an in-depth analysis of state-market and state-society interactions is viewed necessary to determining the state capacity in producing certain policy outcomes. For instance, Evans (1995) coined the term "embedded autonomy" that the rationality of the Weberian bureaucracy is enhanced by the state's linkages and interactions with the surrounding society[30]. Weiss (1998) argues that the informal linkages connecting the state with the society and the market play an important role in determining the state's capacity to transform economies in the increasingly globalized world. This departure from the traditional "strong-state", "state-centric" developmental state model points to the necessity to study not just the state itself, but also the interests of the non-state actors, the process of market development and the state-market interactions.

2.1.1.3 "Reregulation" as a Framework to Analyze Market Development

This thesis employs the theoretical framework of "reregulation" to examine the development of the rare earth sector in China. The term "reregulation" was used first in

[30] According to Evans, these linkages were "the key to the developmental state's effectiveness . . . combining Weberian bureaucratic insulation with intense connection to the surrounding social structure." (Evans, 1995, p. 50)

the early 1980s, primarily in literature studying the regulatory reforms in the U.S. and other advanced economies[31]. The traditional Developmental State model focuses on the state's role as rationally "cherry-picking" target industries to allocate resources and interests. On the contrary, early literature of "reregulation" focused on the political process of devising and implementing regulatory legislations in liberal economies, and the specific regulatory changes which in turn shaped industrial development.

Steve Vogel (1996) was one of the earliest scholars to employ and expand the concept of "reregulation" to explain the process of market expansion and liberalization driven by the state. Vogel studied the reforms in the telecommunications and financial services industries in advanced industrialized countries of the U.K. and Japan in the 1980s. He argues that despite of the widely perceived results of industrial deregulation and market expansion on the surface, the national governments in these countries had in fact reformulated old rules and created more new rules over the market actors. In Vogel's words, "the deregulation revolution of the 1980s and 1990s never happened. The advanced industrial countries moved toward liberalization or freer markets at the same time that they imposed reregulation or more rules". (Vogel, 1996) Vogel emphasizes both the intentions (goals) of the state in implementing the regulatory reforms, and the organization of the state institutions. These two factors, he argues, determine the pattern of regulatory reform each state goes through in market liberalization. On the international level, contrary to the widely perceived notion of globalization eroding the state capacity to regulate markets, Vogel argues that the process of "reregulation" does not necessarily lead to complete integration of the national market.

[31] For an example of the early use of the term "reregulation", see Weingast (1981).

Over time, the concept of “reregulation” has evolved considerably to take on a broader interpretation: the process of the state creating new rules to control industrial development, and ultimately achieve its intended goals[32]. This conceptualization is more distant from the interpretation of the term in early literature, espcially by developmental state theorists (who see the state in the early reregulation literature as a “referee” that does not interfere in the market beyond enforcing regulations). “Reregulation” as a concept has been applied to characterize the industrial development and market liberalization process in not only the western advanced economies, but also less-developed and authoritarian countries, including Latin American[33] and East Asian countries[34]. This thesis employs the concept of “reregulation” in its latest manner.

2.1.2 Contrasting Views on China’s State-Market Relations

The theoretical debate on state-market relations in market economy development is particularly relevant to the case of the transitional economy of China, an emerging economy that has been undergoing incremental economic reform with remarkable development of trade, growth and industrialization. At the time of the establishment of the PRC in 1949, the Communist Party followed the Soviet Union model of socialist industrialization, relying on state command of the production plans and emphasizing collective interests rather than personal interests and individual property rights. The 3rd

[32] For instance, see Hsueh (2012).

[33] For instance, Snyder (2001) studies the politics of reregulation in Mexico’s coffee sector, which has been regarded as a textbook example of successful liberalization reform.

[34] For instance, Hsueh (2011) investigates China's FDI regulations to study China’s integration into the international economy and the role and capacity of the state. Hsueh argues that the Chinese government engages in a liberalization two-step; it combines the liberalization of foreign investment at the economy-wide level with selective “reregulation” at the sectoral level. According to Hsueh, the Chinese government exercises a bifurcated strategy, which reinforces control in strategic sectors and relinquishes control in less strategic sectors.

Plenary Session of the 11th Central Committee of the Communist Party of China held in Beijing on December 18-22, 1978 marked the beginning of the “Reform and Opening” policy and China’s transition from the planned economy to the market economy. During this meeting, Deng Xiaoping, who has been now widely regarded as the founding father of China’s economic reform policy, became the paramount leader of the Communist Party. Since then, the Chinese state has been aiming at building a “socialist market economy”, gradually shifting from administrative command of the economy to fiscal, regulatory and monetary measures of control. The state promotes the development of the private sector, foreign trade and foreign direct investment[35], but the public (state-owned) sector remains the foundation and the major part of the economy[36].

The seemingly contradictory image of China’s economy today warrants additional evidence-based research of the Chinese central government’s relationship with local governments and market actors, and the context under which varying patterns of state-market relationships have emerged. On the one hand, the Chinese government as a single-party authoritarian regime steers national economy on a grand scale through the

[35] This is a major feature of China’s development, compared to the “developmental states” like Japan and South Korea which relies on domestic investment in developing the target industries.

[36] After undergoing the shareholding reform of state-owned firms in the 1990s, the Chinese economy now is characterized by a mix of firm ownership structures with the state maintaining public ownership as the dominate type. The state sector in China consists of three components. The first component includes state-owned enterprises (SOE) that is fully owned by the state through the State-owned Assets Supervision and Administration Commission (SASAC) of the State Council, or by the SASACs of local provincial, prefecture, township, and county governments. The second component includes enterprises which have an SOE as the majority shareholder. The third component includes enterprises which are indirectly controlled by SOE subsidiaries. Altogether the SOEs and their subsidiaries accounts for over 40% of China’s non-agricultural GDP. The urban collective enterprises as well as public township village enterprises are not considered SOEs. (Szamosszegi & Kyle, 2011)

implementation of top-down industrial policy and development initiatives. The central government also directly supervises the operations of 112 central-government-controlled enterprises[37], which dominate even monopolize many strategic industries[38]. On the other hand, issues abound in China's marketization, leading to frequent portrayal of the state as unable to maintain order, penetrate society and market, and enforce the political objectives. There are rampant government official corruption scandals, illegal corporate practices, opportunistic local cadres (who exercise discretion in implementing central mandates), and prevalent industrialization-related environmental and social injustice in China today. Is the central government strong and strategic in guiding the development of market and industries? Or is the central government less capable of achieving its strategic visions than it appears to be, with its power to control market and industry no longer centralized and prone to failure? What are the underlying factors influencing state capacity to control market actors and achieve the state's political goals?

Past studies have presented contrasting arguments and empirical evidence on state-market relations in China's transitional economy. As summarized below, existing literature show arguments for state voluntary retreat/decentralization, state failure, state resurgence, and state fragmentation. This thesis provides an empirical test between these competing views on Chinese state-market relations.

2.1.2.1 State Voluntary Retreat/Decentralization

[37] See the list of central-government-owned companies on the SASAC website http://www.sasac.gov.cn/n1180/n1226/n2425/

[38] Besides the state's control of firms through ownership, particularly relevant to mining is the state's ownership of land and minerals. See Chapter 5 Section 3 for analysis of government control of mining rights.

A prominent scholarly approach, which emerged in the 1990s, sees the Chinese central government having decreased and decentralized control over the market in the process of economic reform. The post-Mao reform era saw the privatization of many state-owned enterprises in urban areas, and the emergence of the township-village enterprises (TVEs), mostly collectively or quasi-privately owned by township and village communities[39] in rural areas in China. The spectacular growth of the TVEs has been hailed by many as a pillar of China's economic reform, prompting a series of county-level studies on privatization and county-level governance. Scholars have drawn from the concept of East Asian developmental state and introduced new terms to characterize the role of the Chinese state, including "entrepreneurial"[40], "regulatory"[41], "corporatist" or "decentralized developmental state"[42]. According to these scholars emphasizing power decentralization and market privatization, the state-led decentralization of political

[39] China has five levels of government. Below the central government are 31 provincial level units (42 million population on average), 331 prefecture level units (3.7 million people on average), 2109 counties (580,000 people on average), and 44,741 townships (27,000 people on average). Furthermore, there are about 730000 villages in rural areas below the township level that are self-governed and do not belong to the formal Chinese government structure (World Bank, 2002).

[40] Blecher and Shue (1996) coined the concept of the "entrepreneurial state" in their study of the Guanghan county government in China. Compared with the traditional developmental state model, the entrepreneurial state does not dis-attach itself from the market by only creating an enabling environment for independent economic enterprises. The entrepreneurial state itself engages in industrial production and creation of new firms, and engages in finance and competition for businesses. For a similar characterization of the Chinese state as the "entrepreneurial state" but at the city level, see the work of Duckett (1998) on the role of the Tianjin city government in management of local real estate and urban commerce.

[41] See Shue (1995) and Blecher and Shue (2001).

[42] For instance, Oi (1999) argues that China's fiscal reform in the 1990s decentralized the central power to manage and extract resources to the local township and village level, and thus provided incentives to local officials to pursue "local corporatist state" and stimulate economic growth through policy, leading to rising output of the private sector. Oi advances the notion of the "local corporatist state" as a type of "decentralized developmental state." (Oi, 1995)

authority from the center to the local governments resulted in the voluntary retreat of central level bureaucratic influence from the economy. Scholars indicate various reasons for the retreat of the central government, including endogenous state institutional changes delegating central fiscal authority to the local governments[43], ideological shifts favoring the market [44] and macroeconomic environment favoring marketization. Power decentralization is viewed positively as contributing to the success of China's economic growth. Decentralization incentivized as well as enabled local cadres to facilitate local market development: county-level and prefecture-level governments not only provide policy incentives stimulating industrial production and creation of new firms within their own jurisdictions, but also become responsible for and take initiatives in obtaining finance and other favorable resources for private businesses[45].

<u>2.1.2.2 State Failure</u>

Another group of scholars who agree with the broad notion of the Chinese state retreating from the market and the social domains have refrained from singing the praise for "decentralization" as a recipe for market growth. Instead, they focus on the

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[43] Montinola (1995) and Qian (1996, 1998) assert that the delegation of fiscal and administrative authority from the center to the local governments resulted in the "Chinese style" of "market-preserving federalism".

[44] Montinola et al. argue that broader ideological shifts from anti-market Maoism to pragmatic, market-oriented Deng ideology in China contributed to the emergence of the "Chinese style" of "market-preserving federalism" (Montinola, Qian & Weingast, 1995, p.48)

[45] For examples of the "local developmental state" where local governments engage in competition for favorable resources for market positions between the localities and mobilize their political authority to promote local development and to develop policy incentives, see Solinger, 1991; Shirk, 1993; Wang, 1994; Nolan, 1995; Oi, 1995; Unger and Chan, 1995; Wong et al., 1995; Huang, 1996.

institutional ineffectuality of the state to impose centralized policy agendas[46], to penalize rent-seeking and cadre corruption, and to maintain coherent redistribution of resources across social groups and across regions[47]. They argue that the central state has involuntarily reduced its administrative control over the market and local governments, due to its lack of capability to build administrative capacities of governance in the post-Mao era[48]. This involuntary withdrawal of the state control contributed politically to the transition from state socialism to market-oriented economy, yet with grave political and social consequences. With respect to the success of the TVEs that "decentralization" scholars employ as evidence, scholars such as Bernstein and Lü (2003) contend that it relies on favorable local conditions – "market access, availability of skills, proximity to large cities, availability of overseas Chinese investors"[49] which are found in the "industrial rural China" in eastern coastal provinces but absent in vast rural areas in the middle and western provinces in China; thus it does not present a full picture of China's economic transition.

One of the most prominent scholars of the "state failure" camp, Minxin Pei frankly labels China as a "local mafia state" (Pei, 2008) and a "parasitic state." (Pei, 2006) According to Pei, the Chinese central state has lost the battle to enforce its goals in

[46] For examples of studies on the central government's failure to impose centralized economic development directives over the localities, see Bernstein and Lü, 2003; Breslin, 1996; Yang and Wei, 1996; Zweig, 2002.
[47] For examples of studies on the central government's failure of redistributing resources, see Baum and Shevchenko, 1999; Park et al., 1996.
[48] For instance, Lü(2000) argues that the Communist Party of China as a revolutionary party is incapable of maintaining centralized enforcement over the party members; under a more relaxed macroeconomic environment provided by the market-oriented reform, the central control over its local government officials has been entrenched, and the party's ability to combat corruption and illegal behavior of its members has been further reduced.
[49] See Bernstein and Lü (2003), p. 8.

critical areas of governance such as the rule of law; local Communist Party officials have been able to use their positions of authority to engage in rent-seeking, alliance with criminal groups, and enhancement of their own welfare at the expense of the regime.

If we use the continuum developed by Evans (1989) on which a state is placed between the two extreme poles of the "klepto-patrimonial" predatory Zairian state and the "embedded autonomy" of the East Asian developmental state, then this group of scholars will put the Chinese state at the intermediate position with both developmental and predatory features, but further towards the end of the predatory state[50], compared to the "decentralization" scholars who would lean towards the other direction (since much of their analysis at the township level resonates with the developmental state model).

2.1.2.3 State Resurgence

Montinola, a major proponent of the "market-preserving federalism" model in the "state decentralization" camp, warned in 1995 about the danger of China's reversal from decentralization[51], that "problems from a central government that is too strong, and this is the danger of recentralization per se. Without further institutional constraints, a financially independent central government would pose potential dangers to the reform's progress over the past fifteen years, especially if run by leaders far less favorable to the reforms than Deng Xiaoping." (Montinola, 1995, p. 81) According to one growing body of literature, recentralization and state enpowerment had in fact already occurred and had been central to the marketization process of the Chinese economy.

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[50] For instance, see So (2007) for the analysis of Chinese state as the "local predatory state".

[51] It is necessary to take this assessment into context: 1995 was the height of the fiscal decentralization in China, as the central government passed a taxation reform in 1994 which separated central and local fiscal revenues and created separate national and local tax-collection administrations.

According to scholars who emphasize the recentralization of the state in leading the marketization process[52], the Chinese state capacity to assert influence over market has been reconfigured, rather than simply reduced. The process of market expansion is the process of the central state's first relinquishing its institutional plan of command over resources to develop the local market economy, and then its re-building capability to intervene in local economies and break local barriers to centralized control. Scholars have indicated various factors enabling the recentralization of the state, including the 2003 bureaucratic reform that recentralizes state power[53], the macroeconomic imbalance and industry supply-demand imbalance which reduces local bargaining power[54], and specific industry/sector features which warrant the state control[55]. One commonality across these views is their focus on certain industries: these scholars argue that the Chinese central government has managed to retain or regain a centralized, hierarchical control within the specific industry sector.

There is disagreement however among the scholars over the extent to which the authority over resources has shifted between the state and the market, and between the different levels of government. Zhang and Heller (2004) argue that in the electricity industry, while the central government allowed the local governments and foreign investors to build a decentralized periphery of plants, the state never relinquished its

[52] See for instance Feigenbaum (2003) for the study of the military's powerful role in the development of China's industries; Mertha (2005) for the study of the development of China's intellectual property protection; Zhang and Heller (2004) for the study of the marketization of China's electricity industry; Lin (2008) for the study of the reform of China's oil and petrochemical industries; Hsueh (2011) for the study of the reform of China's telecommunication industry.
[53] See for instance Mertha (2005).
[54] See for instance Lin (2008); He (2014).
[55] See for instance Hsueh (2011).

structural control through business management of key state-controlled enterprises who continued to exercise state interests through policy favors and market monopolistic advantages. Mertha (2005) argues that the reform of a few key bureaucracies from being under control of local superiors to under control of central administrative superiors led to "soft centralization", which shifted bargaining power from sub-provincial to the provincial level yet provided little benefits to central state authority (contrary to what Beijing expected). Lin (2008) in studying the reform of the petroleum and petrochemical industries argue that macroeconomic surplus, industry supply-demand imbalance and restricted access to financial credit created opportunities for the central government to implement the shareholding reform and impose a centralized hierarchical corporate structure over the industries. Hsueh (2011) argues that the Chinese state has imposed selectively strategic control based on sectoral specifics; in industries critical to strategic state interests, the central government has selectively imposed reregulation and tightened control.

2.1.2.4 State Fragmentation

Finally, a group of scholars whose work relates to the issue of state-market relations in China focus less on the relations between the central state and the local markets, but on the chain of command and fragmentation within the Chinese bureaucracy. Power struggle is not new to Chinese government, as its leaders emerged out of intense power struggle within the communist party in the revolutionary era and in the Mao era of constant political campaigns. These scholars argue that the administrative control of the Chinese government over market has been decentralized in the economic reform since the 1970s, but no changes have effectively limited the rule of the highest central leaders in power. In other words, the fragmentation of the central state power has contributed to marketization and economic development, but has not led to decrease in the state power of governing the market. Horizontal factions within the central government[56] and vertical connections between central factions and their respective local agents have given central leaders the leverage to implement development strategies that they would like to adopt. The pro-market faction and the conservative pro-state-planning faction in Beijing compete with each other through different personnel networks, industry and local connections, leading to different local initiatives and temporal shifts in power balance between the factions[57]. Kenneth Lieberthal (1992, 1995) highlighted the issue of state fragmentation by coining the term "fragmented authoritarianism", capturing the competition between the horizontal (kuai) and vertical (tiao) lines of authority within the bureaucracy. The fragmented authority below the very powerful center leads to cleavages between bureaucratic units below the central government, and creates "policy communities" for certain economic strategies and projects[58].

2.1.3 Contribution to the Debate

The four groups of scholars have contrasting views on the state-market relationships in China's marketization and development process. Assessment of the state's relations with the market has ranged from developmental to parasitic. Similarly, assessment of center's control over the localities has ranged from complete structural enhancement of

[56] Horizontal factions refer to the power struggle between pro-market and conservative central leaders, and between central leaders with different kinds of marketization policy agendas. For instance, Fewsmith (1994) attributed China's transition to market economy in the 1980s to the success of power competition of pro-market leader Deng Xiaoping over conservative leaders including Hua Guofeng and Chen Yun within the central leadership.

[57] See for instance Cai and Treisman (2006).

[58] Also see Lieberthal and Lampton (1992).

control to lack of control to the point of federalism[59]. Yet these views are not mutually exclusive, allowing for a synthesizing, holistic view of the existing theoretical lenses in studying China's market expansion and industrial development.

One way to look at possible co-existence of the different theoretical lenses is that the Chinese state has been constantly modifying itself in the reform process, in order to have economic growth and at the same time maintain its political authority. "For better and for worse, government keep trying throughout the reform era to development investment policy, restructure enterprise incentives, and devise new and appropriate institutions." (Naughton, 1996, p. 95) The institutional legacies of Mao's command economy still lingers and exerts great influence on state policies, while at the same time, new organizational, market and social interests have arisen and created demands that the state must respond to. Thus, studies conducted at different times in China's reform process would yield results that are reflective of the state's priority concerns at the time.

Another possible way to employ the different views together in perspective is that the scholars of different viewpoints tend to focus on the state's interaction with different parts of the Chinese economy, which is huge and highly complex in itself. "State decentralization" scholars, "state failure" scholars and to a certain extent "state fragmentation" scholars tend to focus on the rural economy which has been largely driven by local pro-market cadres. On the other hand "state reregulation" scholars tend to focus on the development of industries which had already built institutional foundations

[59] See for instance Zheng (2007) which argues that with deepening reform and openness China's central-local relations is increasingly functioning on federalist principles.

under strong central control[60] before the reform, and in which the state-owned enterprises continue to receive political favors from the state in the reform era[61].

This thesis, therefore attempts to use the empirical case of China's rare earth industry development to test the validity of these competing but not necessarily mutually exclusive theoretical explanations. The author argues that the Chinese state has been ferociously attempting to recalibrate its control over the rare earth industry production and market development. However, even with recognition of rare earths as strategic resources, the state's capability of imposing control over the market actors has been less than satisfactory and limited by broader political institutional factors not specific to the industry. Below the national level, Beijng's policy reach to the localities was further reduced in regions with specific market, geological and technical features. Thus this case study is largely in line with the view of the "state resurgence" theorists in that instead of voluntarily withdrawing from the market, the Chinese state has implemented strategies to maintain influence over the market actors. Furthermore, this study extends the "state resurgence" observation through applying the "state involuntary failure" argument to look at why Beijing's policies did not work as well as it intended at national and subnational levels.

2.2 Literature on State Capacity

At the most fundamental level, this study of the role of the Chinese state in the development of the rare earth industry addresses the Chinese state capacity amid the

[60] As Fewsmith (1994) argued the rural reform is generally viewed as a result of the bottom-up process, while the enterprise reform is viewed as a result of the top-down process.
[61] See Yasheng Huang(2008)'s analysis of the pecking order of firms in redistribution of market resources in favor of SOEs.

bimodal pressures of domestic reform and global economic engagement. This section reviews existing literature on the definition of state capacity, state capacity to guide economic development, and variation of state capacity.

2.2.1 Definition of State Capacity

State capacity is a complex and critical concept commonly used in political science to denote the ability and quality of governance. There is no clear consensus on how to define or measure "state capacity". Historical and comparative institutionalist research has shown that "possibilities for state interventions of given types cannot be derived from some overall level of generalized capacity or 'state strength.'" (Evans et al., 1985a, p. 353) Theda Skocpol wrote a widely used definition of state capacity, as the ability to "implement official goals, especially over the actual or potential opposition of powerful social groups or in the face of recalcitrant socioeconomic circumstances." (Skocpol, 1985, p.9) The term "state capacity" is often used in relative comparative scenarios. For instance, states with high state capacity are able to provide public goods such as human security, medical and health care, and the social and physical infrastructure that promote development. (Rotberg, 2003, pp. 2-4) States with low state capacity are limited in their ability to provide these goods, leading to low levels of economic development or even state failure. (Rotberg, 2004; Skocpol, 1979) McAdam et al. similarly characterized state capacity as the "degree of control that state agents exercise over persons, activities, and resources within their government's territorial jurisdiction." (McAdam, Tarrow & Tilly, 2001, p. 78)

Among existing literature defining the state capacity of the Chinese state, Shaoguang Wang wrote one of the earliest works on Chinese state capacity and defined state capacity of China in four dimensions: “the capacity to mobilize financial resources from the society to pursue what the central policy-makers perceive as the "national interest" (extractive capacity); the capacity to guide national socioeconomic development (steering capacity); the capacity to dominate by using symbols and creating consensus (legitimation capacity); and the capacity to dominate by the use or threat of force (coercive capacity).” (Wang, 1995, p.91)

Existing works on state capacity have attempted to analyze state capacity by conceptualizing it in several dimensions encompassing fiscal, military and socioeconomic power relations[62]. The different dimensions of state capacity are interrelated, thus past studies all tend to isolate and just study the variables in one preferable dimension. This thesis employs the same approach and focuses on analyzing one dimension of state capacity, the capacity of the state to use its authority to reallocate resources and facilitate economic development.

As Weingast argues, “a government strong enough to protect property rights and enforce contracts is also strong enough to confiscate the wealth of its citizens.” (Weingast, 1995, p.1) The centrality of the role of state capacity in fostering industrial and economic development has long been recognized by many scholars studying development in a wide range of regions employing both qualitative and quantitative approaches. For instance, Polanyi[63] and Tilly[64] pioneered the research on the formation and expansion of the

[62] Although state capacity contains several dimensions, it should be not interpreted as simply the sum of the state’s economic, human and military resources together. For the various concepts of “state capacity”, see Weiss, 1998, pp. 14–40.
[63] Polanyi (1944) first argued for the decisive role of the nation state’s capability to provide social institutions in developing the market economy. Polanyi studied the industrialization of Western Europe and argued that the development of the modern state went hand in hand with the development of modern market economies and that these two

capitalist democracies in the western advanced economies: state institutions and the contentions between state intervention and market forces result in violent social process accompanying liberalization. Gerschenkron[65], another early pioneer of the "static model of industrialization", argued that other major theories in political economy, the modernization theory and the Marxist/Dependency theory, all fail to explain the process of industrialization in the "later-comers" developing countries, in which the state institutions play a decisive role in the industrialization process.

2.2.2 Variation of State Capacity

2.2.2.1 Determinants of State Capacity

Scholars have identified a variety of variables which explain the variations of state capacity in formulating and implementing specific policies across countries or across sectors. Institutionalists employ a broad definition of institutions that includes "both formal organizations and informal rules and procedures that structure conduct" (Thelen & Steinmo, 1992, p. 2), not limited to state regulations and structures. Using this definition, majority of the research on determinants of state capacity can be attributed to institutional factors encompassing both political and economic variables (see e.g. Zysman, 1983, Evans et al., 1985a, Hall, 1986, Steinmo et al., 1992, Weaver and Rockman, 1993, Hall

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changes were inexorably linked in history. Polanyi critiqued the liberal economic theory that the market is a natural form of economic organization of society; instead "laissez-faire was planned". Polanyi argued against self -regulating markets, because unregulated markets would "subordinate the substance of society itself to the laws of the market" (p.71).

[64] Tilly (1975; 1985) analyzed the nation building process of Western Europe and focused on the contention between the state and the social groups.

[65] While the scholars who followed Gerschenkron's "static model of industrialization" predominantly study the newly industrialized countries such as Latin American or East Asian countries, Gershenkron's analysis emphasized that for both early industrializers and late industrializers the strength and the central organization of the state matter fundamentally to economic development (Gourevitch, 1978, p.885).

and Taylor, 1996, Weiss, 1998). Political institution variables include the rules of the bureaucratic recruitment, the existence and the rules of electoral competition, the structure of party systems, the organization of government, and the relations between government organizations of different levels. For instance, “extractive” political institutions in which only a “small” group of individuals have concentrated power can breed rent-seeking activities (the patronage by the rich government-corporate elites who avoid giving up rents and derive higher rents when the rich are in power) and lead to low state capacity to foster development. (Acemoglu et al, 2012) Economic/sectoral institution variables also help determine state capacity in governing industry and markets, including sectoral-specific policy networks linking bureaucracy and social actors (Atkinson & Coleman, 1989), and participation in regional or international economic institutions[66]. Geographical factors, including population density and spatial topography[67] are also found to be of influence to the state capacity to regulate the regions.

Existing work on the state capacity of the Chinese government in the development of commodities industries[68] presents several institutional variables influencing the state capacity. Sun (2006) examined the development of China’s steel industry and argued that “fragmented and uncoordinated Chinese bureaucracy contributes significantly to the inefficacy of policy implementation”. Wright (2012) examined the development of

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[66] For instance, Grande (2001) has argued that Germany’s integration with the larger E.U. economy and economic governance institutions, in other words the “Europeanization” of its innovation policies resulted in declined state capacity to foster innovation in the information technology industry.

[67] For instance see Herbst (2010) for the relationship between population density and topography and state-building success/failures across sub-Sahara African countries.

[68] Since there is no existing work on the Chinese state capacity in steering the development of the rare earth industry, the literature reviewed here concerns existing work that analyzes the Chinese state capacity in steering the development of similar industries that produce and trade primary products instead of manufactured products.

China’s coal industry and argued that the relationships between the different levels of government, shown as the relative independence of the lower level of government from the central and provincial governments in the hierarchy, impact the capacity of the central government to achieve its objectives in the coal industry. Alpamann (2010) studied China’s cotton industry and argued that the state capacity to achieve its objectives in the cotton industry is “mediated by specific patterns of state-economy interactions at the local level…the orientation of local states towards the economy is introduced as the major explanatory variable.” (p.18)

This thesis offers both empirical and theoretical contributions. A review of the existing literature on Chinese state capacity in commodities industries has not found any research that addresses the Chinese state capacity in the development of the industries producing non-ferrous metals (which include rare earth elements)[69]. Thus existing research does not offer explanation on the state capacity in a whole group of industry sectors that produce important natural resources for the Chinese economy and share similar and distinctive administrative patterns in the Chinese bureaucracy[70]. This study offers analysis of the specific institutional variables influencing the state capacity that can be applied to this group of sectors absent in the current literature. Existing studies also focus primarily on the political or economic relationships between the center and the local governments. This study identifies the local deposit geography or production

[69] Non-ferrous metals are metals that do not contain iron in appreciable amounts. Apart from rare earth elements, other notable non-ferrous metals include precious metals such as gold and silver, more common metals such as aluminum, copper and lead, as well as rare metals such as tungsten and cobalt.
[70] In the history of the PRC, because of its over-emphasis on iron and steel production in Maoist era, non-ferrous metals industries have been treated differently from ferrous metals in state administrations.

technology to be variables influencing state capacity, thus adding technical concerns to the existing discussions focusing on political and economic variables.

2.2.2.2 Subnational Variation of State Capacity

Past research of state capacity to steer economic development have mostly focused on variables either at a national-systemic level (studying state capacity variations across countries) or a sectoral level (studying state capacity variation across industry sectors). Research on the sub-national provincial/regional comparison of the state capacity to steer industry development, and the local drivers for such disparity in governance across different regions in a single country[71] remains few in number.

The study of development in a huge country such as China calls for an in-depth understanding of regional political economy of economic growth and industry development[72]. Rithmire (2014) reviewed recent works on regional analysis in Chinese political economy and found that the "new regionalists" in Chinese studies “seek to identify and explain meaningful heterogeneity in the Chinese polity and economy”; but “they go further than simply using subnational cases to generate or test theories about Chinese politics; instead, they propose that subnational political economies in China are a function of endogenous change rather than a reaction to national priorities.” Thus

[71] For instance, Sinha (2003) has studied the subnational variation of state capacity in India, and argues that regional elites’ strategic choices towards central rules and subnational institutional variations lead to differences in economic performance across provinces in India.

[72] According to Wang and Hu (1999), although no province has been excluded from the national development plan in China and every one of China’s 31 provinces experienced strong growth since 1978, performance has varied markedly across regions leading to “uneven development”. Wang and Hu examined political, historical, and geographic factors causing increasing disparity of economic performance across regions and warned of possible severe consequences that could shake the political regime from regional disparity.

contexts specific to the local region deserve greater scrutiny. Studies of subnational political economies in China have more focused on the income disparities between provinces as well as preferential policies received by the coastal provinces, and less on the comparisons of industrial governance between several less-developed inland regions. This thesis aspires to advance in this much desired research direction, by analyzing the factors contributing to subnational variation of state capacity across two less-developed inland regions in reregulating the rare earth industry. A comparison of the state capacity in different regions can yield fruitful analysis of state-market dynamics which are not ideologically or culturally specific to China. The findings of such analysis may also be generalized to inform and help similar works on other regions in other countries and thus make potential contributions to the study of variation of state capacity in general.

2.3 Literature on China's Rare Earth Industry

English-language literature that covers China's rare earth industry have primarily consisted of technical and market analysis of the industry that was largely outside the domain of political science. For instance, the U.S. Geological Survey (USGS) publishes annual report on global rare earth industry, which includes a section on China's rare earth industry, mostly statistics of production and exports and key regulatory changes (quoted from the publications of the Chinese Society of Rare Earths). The Rare-earth Information Center (RIC) at the Iowa State University [73] provided "scientific and technical

[73] RIC was established at the Ames Laboratory by the U.S. Atomic Energy Commission's Division of Technical Information in January of 1966 to service the scientific and technological communities by collecting, storing, evaluating, and disseminating rare-earth information from various sources. In 1968, the support of RIC was transferred to Iowa State University's Institute for Physical Research and Technology through grants from the worldwide rare earth industry. The RIC published two newsletters during its operation, the RIC News and the RIC Insight. According to its description on the archive,

information concerning the rare earths to industry, government, universities, and individuals" from 1966 to 2002, including technical and commercial aspects of China's rare earth mines. A few industry insiders[74] followed China's development as part of global industry analysis, focusing on market supply, technical advance and industry growth and much less on the politics involved.

With the Sino-Japan Senkaku/Diaoyu Island crisis and the alleged halt of China's rare earth exports to Japan in 2010, there has been growing interest in the scholarly and policy communities on China's rare earth industry since 2010. Notably, several U.S. government offices have produced overviews of China's rare earth industry development and summarized state policy interventions[75]. The general consensus in literature is the "criticality" and the "strategic value" of the rare earths. Authors agree that the strategic aspect not only stems from the technical importance of the minerals as raw materials for manufacturing high-tech products[76], but also geopolitical implications of the dominance

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"The RIC News was a quarterly newsletter containing items of current interest concerning the science and technology of rare earths. RIC News was free. The RIC Insight a monthly newsletter, contained more editorial comments, provocative opinions on the future directions of rare earths, later breaking news than the RIC News, and was slanted toward the technological and commercial aspects of the rare earth field". For more information and the RIC database, see https://www.ameslab.gov/dmse/rem/archive.

[74] The "industry insiders" include industry consultants, industry journalists, and scientists and engineers in universities, research labs and firms producing downstream applications. The majority of them do not produce scholarly publications focused on China. For instance, Jack Lifton and Gareth Hatch at the consulting firm Technology Metals Research (TMR) have both worked in high tech industry and followed the rare earth industry development in China in their consulting work.

[75] For instance, see the work of Hurst (2010) at the U.S. Army's Foreign Military Studies Office; Levkowitz & Beauchamp-Mustafaga (2010) at the U.S.-China Economic and Security Review Commission (USCC); Morrison & Tang (2011) at Congressional Research Office.

[76] See Seaman (2010) for the analysis of the criticality of rare earths and its importance to the growth of clean energy industry in Europe. Also see Mancheri et al. (2013) for

of a single supplier in global production and the effect of China's regulations on the global market[77]. Scholars have expressed concerns that China's de-facto resource monopoly can lead to conflicts in interstate relations with consumer countries[78]. The other general consensus is the decline of not just the mining of rare earths but also the entire upstream production in the West. Scholars agree that apart from Chinese policies which propelled industry development, Western governments' negligence of their domestic mining industry and the broader global shift of manufacturing capacity to China[79] also enabled China's fast growth.

Compared to English-language literature, Chinese-language literature has provided considerably richer detail on the nuances of state control and domestic issues plaguing the rare earth industry in China. The general consensus is that despite of strong growth and dominance in global supply so far, the industry suffers from long-term issues including supply-demand imbalance (which leads to chronic production capacity surplus and depressed prices), environmental degradation, illegal production and smuggling, and

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analysis on China's intention and policies on upgrading domestic industry value-added production to make better use of REEs.

[77] See Abraham (2012)'s analysis from Japan's perspective on the geopolitical repercussions of shifting reliance on traditional fossil fuels to an undefined mix of alternative energy sources and the implications of rare earth metal supply for green technology development.

[78] See Nakano (2011) for Japan's response to China's regulations over rare earth export and alleged halt of rare earth export to Japan in fall 2010. Nakano argues that the halt of Japan-bound export in 2010 was a turning point that signified the starting point of a new phase in clean energy competition and transformed Sino-Japan trade relations into a prosperous rivalry with an undertone of mistrust. Also see Ting & Seaman (2013)'s study on the international implications of China's regulations, which argue that dispute over rare earth trade can lead to greater inter-state tension.

[79] See Gschneidner (2011), director of the U.S. DOE-funded Ames Research Lab, who remarked about the decline of the U.S. workforce in rare earth mining and processing.

political contentions between the center and the local regions over industry consolidation[80].

The Chinese state rhetoric focuses on the necessity to curb environmental damage and to effectively protect and rationally utilize rare earth resources. (PRC Information Office, 2012) The PRC State Council published a whitepaper on the state-led development of China's rare earth industry, entitled *Situation and Policies of China's Rare Earth Industry*. (PRC Information Office, 2012) This authoritative overview focuses on the domestic issues regarding China's rare earth industry development which warrant state intervention in production and justify state restrictions of export. These issues include over-supply of primary products (relative to global demand), over-capacity of processing facilities, low price relative to the strategic value, illegal mining and smuggling, and rampant environmental degradation. The whitepaper denies the speculation that the Chinese government has been using natural resources as weapons in global competition over high-tech manufacturing or in gaining leverage in inter-state political or territorial disputes. Another authoritative account from Miao Wei (Miao, 2009), current Minister and then Deputy Minister of the MIIT, explains that the MIIT would implement a series of policies to increase the "proper use" and regulation in 2009 of rare earths. Miao highlighted several issues that warranted immediate action: low efficiency in resource use, environmental pollution, lack of indigenous innovation, export

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[80] For instance, see Su (2009), Ma (2012) and Chen (2012), for first-hand accounts of China's rare earth industry development. Su is the Deputy Director of the Office of Inner Mongolia Autonomous Region in Beijing, and formerly the Director of the Baotou Rare-Earth Hi-Tech Industrial Development Zone. Ma is former President of Baotou Rare Earth Research Institute. Chen is the Director of the Academic Department of the Association of China Rare Earth Industry.

primarily of low-value-added products, and lack of regulatory control over mining and illegal production.

Current literature points to several interesting points of debates and gaps. First of all, there is still a lack of systematic and empirical analysis on the role of the state along the trajectory of development and the effect of state reregulation on industry production through fieldwork. Chinese scholars have reported extensively on the state's intervention in the market prior to 2008, and the focus tends to be specific industrial policies and regulatory changes. This study enriches the understanding on the role of the state, by systematically analyzing both industry-specific goals and policies as well as broader political institutional changes imposed by the state. In analyzing the current state intervention, scholars mostly analyze secondary sources of information such as state bureaucrats' speeches, government reports and media reports; therefore they miss the empirical evidence one could only gather from primary fieldwork about the policy implementation. This study also fills the gap.

Secondly, existing literature contains varying arguments about the motivations of the Chinese state in implementing restrictive or more controlling policies over the industry. Scholars have a general consensus on rare earths viewed as "strategic metals" in the eyes of the Chinese state. Scholars generally agree on the concerns over environmental degradation and resource depletion as claimed by the Chinese government whitepaper. But different narratives on why the industry warrants central policy intervention (i.e. what strategic value is there for the state to intervene) have also emerged. For instance, Mancheri et al (2013) focuses on the state's goal to build a national innovation production chain. Biedermann (2014) sees the state policies as tools to incentivize foreign corporations to invest in China with possible high technology transfer. Ting & Seaman (2013) argues that Beijing aims to reap economic and geopolitical benefit from its monopolistic position in global production. Wang (2011) argues that Beijing needs to protect China's national security from being compromised by excessive Western purchase of its strategic resources. Wuebbeke (2013) examined the different narratives, and argued that the "environment narrative" - concerns for depletion of non-renewable resources and environmental degradation, and the "development narrative" - the desire to develop the downstream industries, together outweigh the "geopolitical narrative" - using resources as weapons in political disputes. Hao and Liu (2011), and Hayes-Labruto et al. (2013) similar argue for the importance of domestic stakeholder interests in China's regulation over the rare earth industry, as well as socioeconomic and environmental concerns of industry production, rather than accusations of resource nationalism. This thesis takes a historical view and analyzes the goal of the state in sponsoring the industry development across four decades since the start of its economic reform and opening up. A mix of interrelated political, economic and socio-environmental concerns that grew out of the industry's development experience drive the state rationale for industry reregulation. These concerns together reflect the "strategic" value of rare earths in the eyes of the Chinese state.

Thirdly, there has been little subnational level of analysis about policy formulation, policy implementation, market structure and firm behavior in the rare earth industry in China. Existing studies tend to focus on state regulatory changes and their influence on production and trade at the national level, or on the influence of national policies on trade and political relations between China and the West. Local production regions are treated either as black boxes, or as a single case without structured comparison with other regions. This thesis fills this gap by analyzing comparatively the political economy of rare earth industry in North China's Baiyun-Ebo region, and in South China's Gannan-Yuebei region. The subnational level analysis of the barriers to state reregulation yield findings that can help us understand the role of the state in development at the regional level.

CHAPTER 3 RESEARCH DESIGN & METHODOLOGY

This chapter outlines the research design and the data collection process. The author presents evidence through process tracing, within-case comparison across regions, and framing the research hypothesis in the broad theme of state capacity in economic transition. The data employed are mainly collected from in-depth interviews, field visits and secondary sources during field work in China.

3.1 Research Design

3.1.1 Sectoral Analysis

This thesis follows the sectoral analysis[81] approach to study the role of the state in industry development. This study of China's reregulation of a single industry of rare earths constitutes a "crucial case study"[82] that advances theory testing and theory development. The case study also has intrinsic practical value to help remedy the understudied rare earth sector in China that produces monopolistically some of the most

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[81] Sectoral analysis approach is commonly used in industry studies and establishes a set of causal and measurable relationships between market structure, firm conduct and industrial performance. In contrast to firm level research, sectoral analysis researches the industry as a whole and emphasizes the history and evolution of the industry. See Kitschelt (1991).

[82] The crucial-case method, first proposed by Harry Eckstein (1975), is a method that utilizes one single crucial case that "must closely fit with a theory if one is to have confidence in the theory's validity, or conversely, must not fit equally well any rule contrary to that proposed" (p. 118). Since Eckstein's influential essay, the crucial-case approach has been used in a multitude of studies across several social science disciplines and has come to be recognized as a staple of the case study method (George & Bennett, 2005). Here the rare earth industry case is used as a crucial case for the theory of state reregulation.

critical natural resources in the world yet has not been well understood in existing literature.

3.1.2 Process Tracing

This study takes a chronological approach to examine the trajectory of the state involvement in the production and trade of rare earths in China. Process tracing is considered as a fundamental qualitative analysis tool, "the systematic examination of diagnostic evidence selected and analyzed in light of research questions and hypotheses posed by the investigator." (Collier, 2011, p. 823) The author identifies the causal mechanisms embedded in the sequence of events in the marketization and development process through comparison of the state reregulation efforts and outcomes in three periods.

3.1.3 Within-Case Subnational Comparison

The regional comparison allows this single-industry study to incorporate the Most Similar Systems Design, a research design commonly used in the study of comparative politics to test hypothesis[83]. The study compares two sub-national regions with similar cultural, institutional and structural national features: the mining regions in North China and South China that have different outcomes under the same state-led reregulation. This within-case comparison allows the author to identify empirically what factors lead to differences in state capacity of control, shaping different regional models of industry development.

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[83] Based on J.S. Mill's System of Logic (1843), the Most Similar Systems Design method examines cases that are as similar as possible, except on the outcome (the dependent variable). The differences between the cases (independent variable) lead to the different outcome.

3.2 Data Collection and Analysis

This study primarily employs data collected during 9 months of field research in China. Because of the political sensitivity surrounding rare earths as strategic minerals as well as the ongoing nature of central government policies, the majority of the interviewees and the firms that I visited requested not to be directly quoted or to be quoted without naming their specific affiliations. Thus, the study used a combination of primary evidence (expert interviews, field trips) and secondary evidence (supporting the primary evidence) to support the findings.

3.2.1 Fieldwork in Beijing (December 2012-February 2012; June 2013)

As the capital of China, Beijing is home to the PRC central government and the Central Committee of the ruling Communist Party of China (CPC), which have overseen the development of the rare earth industry since the founding of the PRC in 1949. Beijing is also home to headquarters of major state-owned mining companies (such as China Minmetals Corporation, CHINALCO, China Nonferrous Metals Mining), major industry associations and consulting firms, top national research institutes and universities, and state-owned news agencies. The author conducted in-depth semi-structured expert interviews with 15 representatives of stakeholders of the rare earth industry, including government officials, state-owned firm managers, staff members of the Association of China Rare Earth Industry, academics in universities and national research institutes, industry consultants, and industry journalists. These interviewees had relatively closer ties to the central government compared to interviewees in the local regions and could be seen as key informants. Interviews focused on the history of state involvement in industry development, factors leading to past regulatory failures, formulation process of current central policies, policy implementation results and their personal experience of interacting with other central and local industry stakeholders. Specifically, interviewees were asked to identify the key factors which they believe motivated the state to control the industry and to identify the factors influencing the central government power to enforce control over the local regions and the market.

In order to understand the historical trajectory of market development and state policies, the author also studied secondary materials hosted at the State Archives Administration, the National Library of China and the Peking University Library in Beijing[84]. Secondary sources include relevant historical policy documents, newspaper articles, trade reports and scholarly analyses which are largely unavailable to scholars in the U.S. The author also collected qualitative newsletters, booklets, commentaries and scholarly reports published by industry experts and consulting groups in Beijing.

For quantitative data, the author collected data from several official sources published by the central government or government-affiliated institutions in China that produce fact-based reviews, industry analysis and science and technology analysis. Key datasets include production volumes and quotas, export volumes and quotas, market demand structure and volumes, industry capacity and merger and acquisition activities within the industry. The State Rare Earth Office publishes *Annual Review of China's Rare Earth Industry* (《中国稀土年评》), which reports on industry and market statistics and key events in the rare earth industry each year. The State Rare Earth Office also sponsor a peer-reviewed journal *Rare Earth Information* (《稀土信息》) jointly with the Baotou Research Institute for Rare Earths. The official journal publishes

[84] Peking University College of Chemistry hosts the State Key Laboratory of Rare Earth Materials Chemistry and Applications.

information, events, news, expert opinion and market analysis of the industry. The Chinese Society of Rare Earths (CSRE) publishes the *Chinese Society of Rare Earths Yearbook* (《中国稀土学会年鉴》) which summarizes chronologically key industry events each year and provides annual industry statistics. CSRE also publishes the *China Rare Earth Information*, an English newsletter to overseas subscribers reporting on industry news, statistics, technical applications and government policies. CSRE also publishes two peer-reviewed scientific journals reporting on the cutting-edge technology progress, *Journal of the Chinese Society of Rare Earths* and *Rare Earths*. Not specific to the rare earth industry, the Ministry of Land and Resources publishes *China Nonferrous Metals Mining Industry Yearbook* (《中国有色矿业年鉴》) which provides annual overviews of industry development and government policies concerning nonferrous metals, *China Land and Resources Statistics Yearbook* (《中国国土资源统计年鉴》) which provides overview on China's land and natural resources. The author obtained data from these publications hosted at the National Library of China.

3.2.2 Fieldwork in Five Local Provinces related to China's Rare Earth Supply Chain (Feb. 2013- May 2013; July 2013-August 2013)

My field research in local sites involves four provinces and one autonomous region[85] with advanced rare earth supply and material production capabilities. (See Figure 3 for the geographical locations of all five provincial units) In Northern China I conducted fieldwork in Inner Mongolia Autonomous Region, home to the prefecture-level city of Baotou known as China's "Rare Earth Capital of the North" and the Baiyun-

[85] An autonomous region is a region which is populated and governed by ethnic minorities and has the same status with provinces in the Chinese political system. The Inner Mongolia Autonomous Region is the only autonomous region, the rest four are provinces.

ebo Mine, the largest rare earth mine in the world. In Southern China I conducted fieldwork in four provinces, specifically: 1) Jiangxi Province, home to the prefecture-level city of Ganzhou known as the "Rare Earth Capital of the South", containing major ion-adsorption rare earth mines in South China; 2) Guangdong Province, which has rare earth mines along the border with Jiangxi Province, as well as clusters of downstream companies; 3) Anhui Province, which has the largest rare earth alloy production cluster in China; 4) Zhejiang Province, which has the largest cluster of REE-enabled permanent magnet production in China. Despite the difference in locations, data collection in each area covered common topics and followed the similar procedures as outlined below.

Figure 3 Fieldwork Regions[86]

3.2.2.1 In-depth Interviews

In each province, the author conducted 5-10 semi-structured expert interviews with representatives of local rare earth industry stakeholders. The stakeholders included local government officials, corporate managers of local rare earth firms, small business owners, staff members of local industry associations, industry experts, consultants and local academics. The interview questions were open-ended and tailored based upon the interviewees' experience in the rare earth industry and their interaction with other stakeholders (including the central government, the local government or other market

[86] The regions circled in blue circles represent the capital of Beijing, as well as the five local provinces and autonomous regions where I conducted fieldwork.

actors). The questions focused on the interviewees' perceptions of the central government regulation, their understanding of the mechanism of control the central government has imposed on local markets and governments, as well as the outcome of local industry development. The sampling of interviewees followed mainly the snowballing method: the author obtained access to interviewees through mostly personal referrals and sometimes cold calling. The author also attended the Shenzhen International Rare Earth Materials & Applications Industry Exhibition held in Shenzhen, Guangdong Province in June 2013, as well as the 5th Baotou Rare Earth Industry Forum held in Baotou, Inner Mongolia in August 2013. The author conducted interviews with some participants at both forums. The possible sample bias in selecting the expert interviewees is mitigated by a triangulation of interview data with interviewees' published talks and other public documents, as well as a triangulation of interview data with data from secondary sources.

3.2.2.2 Field Observation

The author visited seventeen prominent production sites in the rare earth industry production chain in five local provinces. The sampling of mines and factories to visit followed the snowballing method; however, the author purposefully sampled to have as much variation in terms of firm ownership (local subsidiaries of central state-controlled firms, local-government-controlled firms and private firms) and the firm's position in the rare earth industry production chain (mining, smelting, midstream products, downstream applications). The author collected information about production history, firm ownership and corporate structure, major markets and major products, production methods, environmental protection measures, environmental consequences of production, relationship with the local community, and major government policies that have influenced company operation. The author conducted direct observation of production process as well as informal conversations with local managers and workers when allowed.

3.2.2.3 Data Collection from Secondary Sources

The author also collected data from archives and secondary sources in the production regions. The author visited the Baotou City Archive Bureau, the Baotou City Library, the Ganzhou City Archive Bureau, the Ganzhou City Library and the Guangzhou City Library. The author collected declassified local government documents and reports, local newspaper articles, local chronologies, yearbooks and industry publications. In Hong Kong the Universities Services Centre for Chinese Studies in the Chinese University of Hong Kong also kindly allowed the author to use their “insider collections room” to view their historical collection of “Jingji Yaocan”. The insider publication published by the Development Research Center of the PRC State Council contained expert comments to the central government on economic affairs, including on China’s rare earth industry. The author coded the qualitative data from these secondary sources by themes emerging from the materials, including production and export, government policies and initiatives, industry consolidation, industry upgrading and downstream market demand, environmental pollution and community response, technology transfer and intellectual property rights protection. The author also collected quantitative data about local industry production, trade statistics, market fluctuations, and environmental costs. The secondary data supplements expert interviews and field observation to help analyze the local development trajectories and the differences in the central government’s capacity of control over the local governments and local market actors.

CHAPTER 4 RARE EARTH INDUSTRY: AN ANALYSIS OF GLOBAL SUPPLY AND DEMAND

This chapter explores the influence that China's state intervention in the rare earth industry may have on global markets and downstream industries, through analyzing the global supply and demand of the rare earths and China's position in the global production chain. The first section provides an overview of the rare earths, a group of non-renewable minerals as raw materials with many high-tech applications. REEs differ from other natural resources due to its criticality of supply on multiple dimensions (geographical concentration of deposit, demand structures, substitutability/recyclability, technology intensity of production). The second section outlines the global REE deposits and production by country. The third section outlines China's REE deposits and two major production regions this thesis studies, Baiyun-Ebo region producing primarily light rare earth elements and Gannan-Yuebei region producing primarily heavy rare earth elements. The fourth section analyzes current non-China junior[87] mining projects. The author predicts that non-China junior projects face financial, technical, regulatory and socio-environmental hurdles to commercialize their operations, and thus they are unlikely to replace China's leading position in global supply. The fifth section analyzes the global REE market demand by sector and by country. The sixth section outlines the rare earth

[87] "Junior" is a term frequently used by investors in the mining industry. A junior exploration company targets mineral deposits that are believed to have significant potential for future supply, and becomes the critical player to develop newly found deposits into final production (which has a time lag of several years to decades). A junior mining company, also referred to as "junior miner" or just "junior", is typically small in size and carries high risk associated with commercialization of new deposits. For example of the usage, PwC publishes annual report on the junior mining companies (PwC, 2014)

industry production chain using the examples of the production chain running from mining primary ores until downstream production in new energy industries. The final section analyzes China's position in the upstream, midstream and downstream of the global production chain. Using the examples of wind energy and electric vehicle industries, the author shows that China has technical and market dominance in upstream rare earth mining, smelting, alloy making and low-end component production, whereas advanced industrialized countries dominate high-end manufacturing in downstream industries. Such mutual dependence across the production chain means that China's reregulation has profound influence across industries and national borders. This also forms the basis of the technical rationale for the state to enhance its control over the industry, in order to preserve the strategic value of rare earths.

4.1 Criticality of REEs

Rare earths, or more commonly referred to in the abbreviated version as REEs (rare earth elements) (shown in Figure 4) are among the most critical raw materials for modern technologies. Rare earth elements (REEs) include 17 elements in the periodic table, namely scandium (Sc), yttrium (Y), lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu). Y plus Tb-Lu form the group commonly called heavy rare earth elements (HREEs); Sc, La, plus Ce-Gd form the group of light rare earth elements (LREEs). HREEs are generally less abundant than LREEs[88].

[88] See APS & MRS (2011) for a technical review of the REEs as critical metals for the development of a variety of industries in high-tech fields.

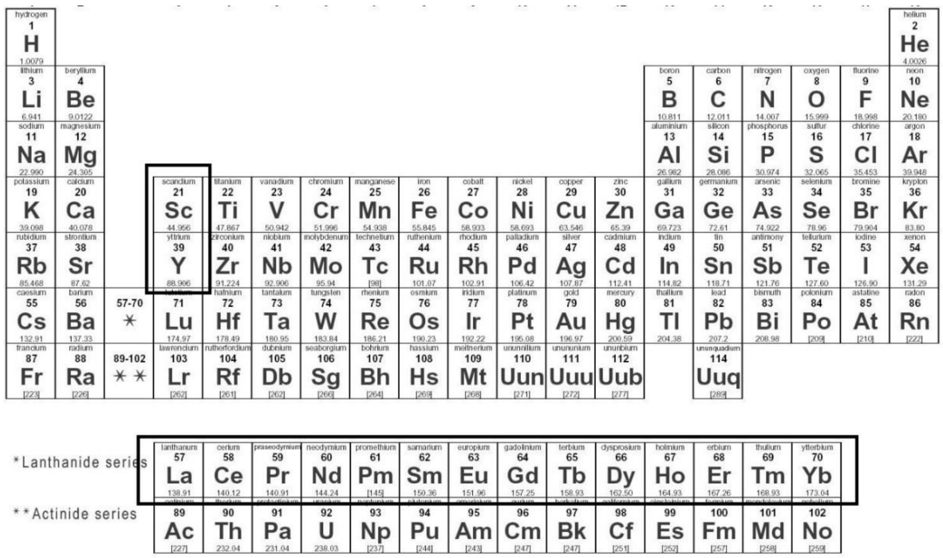

Figure 4 REEs in Periodic Table

REEs have attracted particularly significant attention as the "critical mineral"[89]. What made REEs so special, in comparison with other important types of natural resources[90], such as Lithium and other minerals used in developing new technologies[91], or energy resources such as crude oil and natural gas? The REEs have specific properties in high concentration of market supply, technical demand structure, lack of substitutability and recyclability, as well as complex production chain, thus their "criticality" has multiple aspects, making it hard to mitigate the risk of supply.

4.1.1 Resource Supply Concentration

[89] In U.S. DOE's Critical Minerals Strategy (DOE, 2010; DOE, 2011), REEs are featured prominently as critical minerals, with five elements (Dysprosium, Neodymium, Terbium, Europium and Yttrium) identified as critical in both short-term and long-term.

[90] Natural resources are, by definition, "stocks of materials that exist in the natural environment that are both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing" (WTO, 2010, p. 5).

[91] Lithium has been used in producing lithium-ion batteries, a relatively new and rapidly growing battery technology to store energy in electronics products.

In terms of resource supply concentration, currently the global REE supply is primarily concentrated within the single country of China. Unlike other industry metals, the market for rare earths is highly localized, opaque and fragmented. Within China, purchase of rare earth products are mostly completed through professional trading companies, direct contracts with state-granted suppliers, or the local “black market” where pricing can be substantially lower than the open-market government-set price. There has not been a fully functional international exchange for the rare earth products. Government-sponsored metals exchanges trading rare earths have sprung up since 2011, including Baotou Rare Earth Exchange (in Inner Mongolia) which started in 2013, Jiangxi Ganzhou Rare Metals Exchange (in Jiangxi Province) which started in 2011, South Rare Precious Metals Exchange (in Hunan Province) which started in 2012, and the existing Bohai Commodity Exchange (in Tianjin) which started trading rare earth products in 2014. Participation by domestic mining firms in these exchanges has been highly localized as well. The author observed during field work that firms in Jiangxi Province largely refrained from participating in the Baotou Rare Earth Exchange sponsored by Baotou Iron & Steel Company. A private metal exchange, Fanya Metals Exchange, was in operation since 2011 and partnered with metal companies and banks and allowed for trading of rare metals between metal companies and traders. The exchange then sold a derivative product “Ri Jin Bao” through commercial banks to ordinary Chinese investors whose funds were used as loans to traders. Fanya was exposed for questionable practices of only buying and holding metal stocks and shadow financing practices using metals as collateral for multiple loans, and its operation was discontinued in April 2015. (Hornby, 2015)

4.1.2 Resource Demand Structure

In terms of resource demand, unlike crude oil or natural gas, REEs have been nicknamed the "vitamin" of modern manufacturing. Just like the vitamins essential to the human health that are not required in large quantities, the demand for these elements in most end products are not large in quantity, yet crucial for proper and superior technical performance. The demand can change overtime due to both new technology development and REE availability. REEs often co-exist with each other in the earth's crust; thus the demand for one specific rare earth element may not only increase its own supply, but also the supply of other co-existing rare earth elements, decreasing their production costs and increasing availability for consumption.

4.1.3 Resource Substitutability and Recyclability

In terms of REE substitutability and recyclability, there has been a lack of industry awareness and investment in substitution and recycling compared to other types of natural resources. Because China supplied comparably low-priced REEs to the rest of the world for almost three decades, the market price for rare earth products has been low enough for downstream firms to justify not spending considerable resources on developing substitution and recycling.

From an industrial ecology perspective, the recycling of REE is a more appealing choice because: 1) Recycling ensures a secure while small supply for the end users from the product stock[92]; 2) Recycling mitigates the supply-demand imbalance inherent in the

[92] The National Institute for Materials Science of Japan says that used electronics in Japan hold an estimated 300,000 tons of rare earths. (Tabuchi, 2010) Although the amount is small compared to the amount of rare earth consumption by Japanese firms, it could help alleviate supply risks for these critical REEs if successfully recovered.

rare earth market[93]; 3) Recycling will not yield radioactive or environmental hazards common in the mining and smelting processes in rare earth production. Yet until 2009 no indications of any post-consumer recycling of rare earth containing products could be found. (Schuler et al, 2011) After China tightened control on production and export, there has been significant amount of research on recycling and probable extraction processes[94]. In April 2012, Honda became the first company to announce a plan of massive recycling, to recycle REEs from electric vehicle batteries which contains lanthanum (one of the most abundant REEs and also one of the largest in demand volume) [95]. By 2013 still less than 1% of REEs are being recycled. (Binnemans, 2013) With respect to the REEs in critical demand defined by the U.S. Department of Energy (Dysprosium, Neodymium, Terbium, Europium and Yttrium), there has been no evidence of sustained commercial recycling. There are not only technological difficulties involved in developing massive recycling of comparable quality, but also practical issues in implementing them on a large scale, such as the inefficient collection of recyclable materials and the lack of economic incentives for most firms to participate. According to Rademaker et al. (2013), with current recycling technology and infrastructure, waste flow from end product of permanent magnets would remain small relative to the global REE demand, meaning that recycling alone is unlikely to significantly contribute to global supply.

[93] REEs occur in different ratios in ores and co-exist with each other, so the mining for one particular element will generate large amounts of other elements that need to be sold. Recycling can mitigate the demand for particular elements and thus reduce the need to mine more primary ores.

[94] The Japanese government has invested $38 million in research related to rare earth recycling (Gschneidner, 2011b).

95 See the Honda news release http://www.hondanews.info/news/ja/corporate/c120417.

Substitutions of the REEs are available for many applications, yet they are unlikely to be adequately effective and there is no substitute for one chemical element that is suitable for all its major uses. (Graedel et al, 2013) For instance, substitution of the REE-enabled NdFeB permanent magnets has been undertaken by some downstream producers, yet such substitution sacrifices the high performance that NdFeB permanent magnets have compared to substitutes (such as Sm-Co, ferrite and Alnico magnets). In some cases of REE end products, product designs can be changed to reduce the overall amount of REE-enabled materials required and thus to decrease the amount of REEs required. For instance in electric vehicle production, Tesla Motors has developed an induction motor for its all-electric Roadster which uses electromagnets, but it is larger and heavier than motors that use REE-enabled permanent magnets. Researchers in the U.S.[96] , the E.U.[97] and Japan[98] are currently working on finding low-cost and abundant replacement materials, and the results are highly preliminary. (Piesing, 2013)

4.1.4 Technology Intensity of Production

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[96] U.S. DOE's Advanced Research Projects Agency-Energy (ARPA-E) REACT program, short for "Rare Earth Alternatives in Critical Technologies", is responsible for finding low-cost and abundant material alternatives.

[97] The Ad-Hoc Working Group on Defining Critical Raw Materials, a subgroup to the Raw Materials Supply Group (an expert group of the European Commission) publishes criticality analysis of raw materials every three years. In 2010, the first criticality analysis of raw materials was published which included analysis of 14 critical raw materials including both LREEs and HREEs. In May 2014, the European Commission published a Communication on the updated critical raw materials list and the implementation of the Raw Materials Initiative.

[98] The Minerals and Natural Resource Division under the Agency for Natural Resources and Energy, a subunit of Japan's Ministry of Economy, Trade and Industry released Strategy for Ensuring Stable Supplies of Rare Metals in 2009. The Strategy identified recycling and development of alternative materials as two of the four focus approaches to mitigate supply risk. (METI, 2009)

REEs are different from other types of industrial raw materials, for instance, crude oil which has a standardized production chain from deposit extraction to pipeline transportation, refining and processing. The production of rare earth products need to undergo complex processes of mining, sorting, smelting, purifying and further processing in order to be manufactured as compounds suitable for downstream consumption. Thus one cannot simply take the production technologies from one deposit and use them on another deposit to obtain rare earth products. Without necessary technical and infrastructural support, it is impossible to build up a complete REE supply chain within a country in a short time. While production in general requires a level of technology sophistication hard to attain in a short time, not all types of REEs or all REE deposits are created equal. Contingent upon the geological conditions of the deposit and the element (each has a unique production chain from the ore to the final product), the techniques of mining and smelting can vary greatly. This creates differences in market entry, in both technical barriers (some ores are closer to the surface[99] or geologically easier to be extracted than others) as well as financial barriers (more expensive technologies of production prompts higher cost estimation and lower investor interests in mining).

4.2 Global Supply of REEs

Despite of the name of “rare”, the rare earth elements as a whole have a fairly large and dispersed deposit around the world (see Figure 5 for a breakdown of estimated reserves by country and region). According to the estimates of global reserves by the USGS in 2014, major countries with large rare earth deposits are China (about 40%),

[99] An example would be the ion-adsorption clay deposit in Jiangxi province in South China. The deposits are located very close to the ground surface.

Brazil (about 16%), the U.S. (about 10%), India (about 2%) and Australia (about 2%). The Soviet Union before its collapse was also a major rare earth producer. The estimated rare earth deposits in the Commonwealth of Independent States (including a current producer Russia) by the USGS in 2012 was 19 million tons in REO equivalent unit, about 17% of the global reserve estimate. (USGS, 2012) It should be noted that the USGS only estimates reserves that can be economically extracted or produced with existing technology. In addition, USGS does not require reporting compliance with technology standards used by companies listed on specific international stock exchanges. Thus these figures can have significant differences from an estimate of all reserves available in the earth crust, or an estimate which requires compliance with a specific reporting standard.

The three most common forms of rare earth deposits in the world are bastnasite, monazite and xenotime[100]. Bastnasite deposits are flurocarbonates which usually contain abundant LREEs and fairly low HREEs, and which tend to have high levels of Cerium, Lanthanum, Yttrium and Neodymium. Production from bastnasite deposits currently accounts for about 94% of global rare earth production in volume, including major deposits in Mountain Pass mine in California in the U.S. and deposits in Baiyun-ebo mine (which also includes monazite deposits) in Inner Mongolia in China. Monazite deposits constitute the second largest type of deposits, and they are found in in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States. Monazites are rare earth phosphates which may contain a variety of REEs, usually including higher levels of LREEs (such as Cerium, Lanthanum) than HREEs. Xenotime deposits are rare earth phosphates which are similar to monazite deposits, but they

[100] For more information, see “rare earth element” entry in the Encyclopedia Britannica at http://www.britannica.com/science/rare-earth-element.

typically contain higher levels of Yttrium and HREEs including Dysprosium, Ytterbium, Erbium, and Gadolinium. Besides these three major forms of deposits, the ion-adsorption clay deposits in South China are unique deposits rich in Yttrium, Dysprosium, Terbium and Samarium, as well as high concentration of Neodymium and Praseodymium in some areas.

Since the 1980s global rare earth production has migrated to China, resulting in a peak of over 97% of global production from China in the 2000s (See Figure 6 for the historical shift of location of production of rare earth oxides). As China has blocked foreign firms from investing in rare earth mining or smelting in China since the late 1980s, foreign firms either import rare earth products from Chinese firms and traders, or set up local joint ventures with Chinese firms to get access to the smelting products. Due to China's tightened control over production and export since 2008, countries such as the U.S., Canada, Australia and South Africa have restarted rare earth production or started supporting mining exploration. As a result, according to the USGS statistics, in 2013 China's mine production accounted for about 90% of global production (see Figure 7).

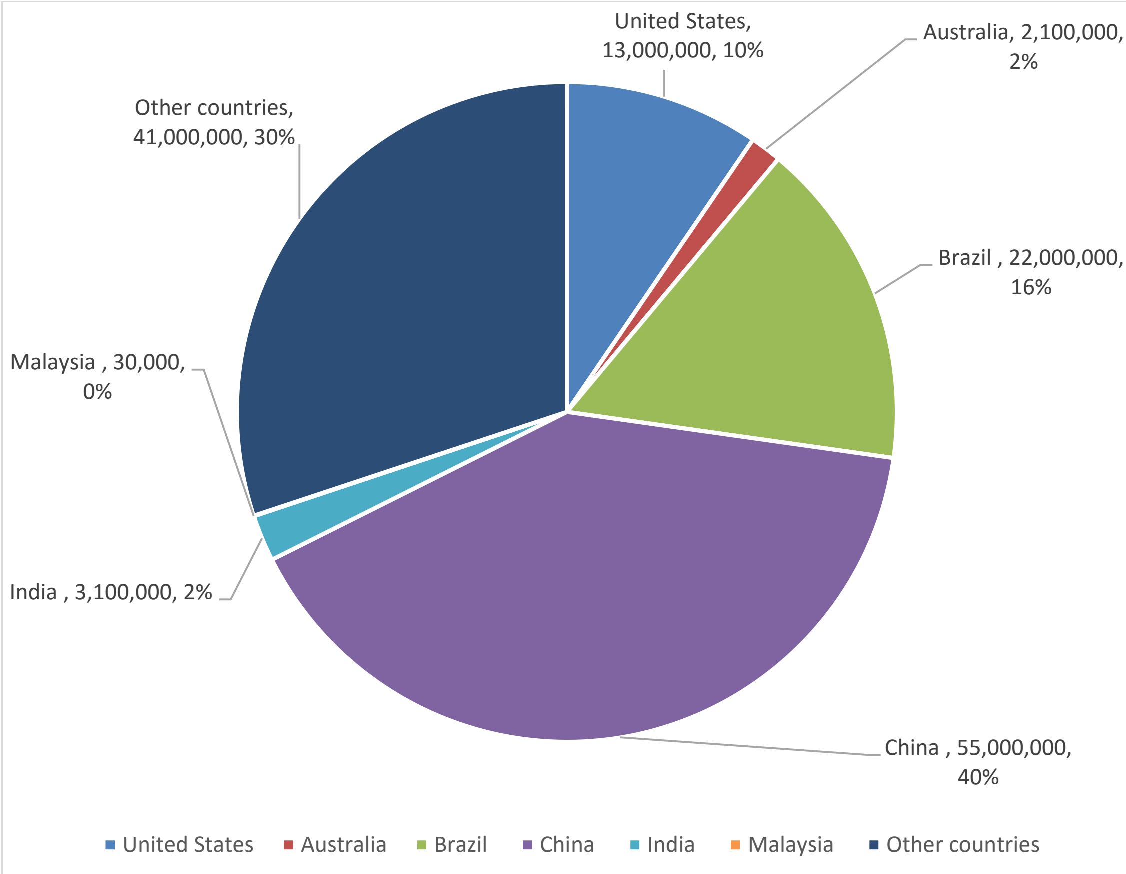

Figure 5 Global Rare Earth Reserves by Country/Region[101]

(Unit: metric tons of rare-earth oxide (REO) equivalent)

[101] The reserves are defined as part of the reserve base that could be economically extracted or produced with existing technology. Other countries include two producing countries, Vietnam and Russia. Data Source: (USGS 2014).

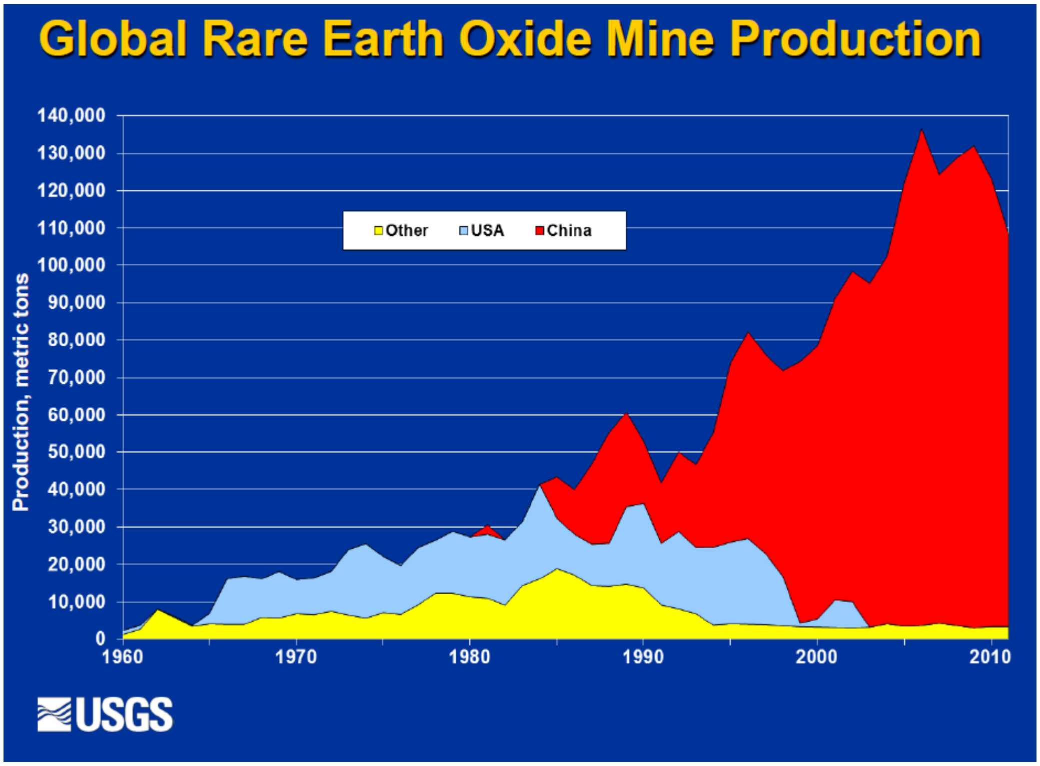

Figure 6 Global Rare Earth Mine Production Trend (1960-2010)

(Public domain image from USGS[102])

[102] USGS (n.d.). *Global Rare Earth Oxide Mine Production*. Retrieved from http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/ree-trends.pdf

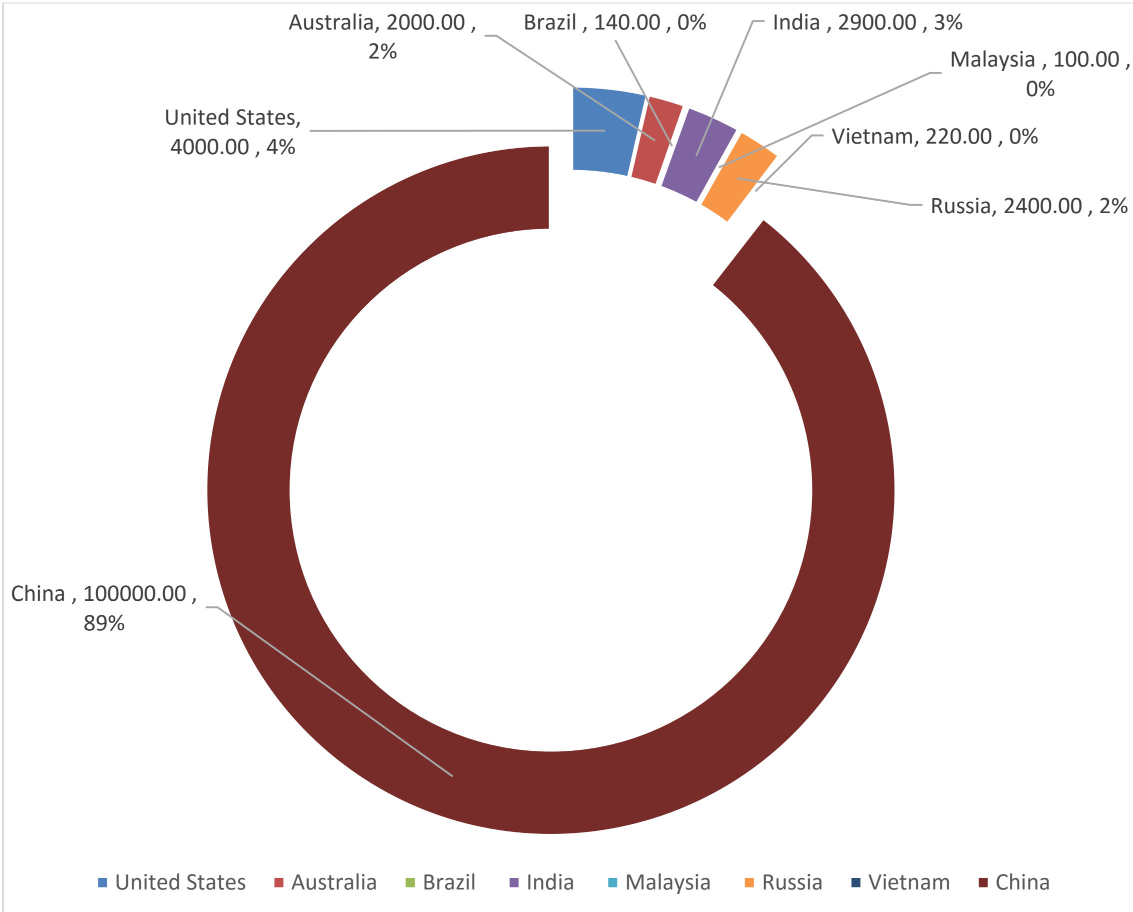

Figure 7 Global Rare Earth Mine Production by Country/Region in 2013[103]

(Unit: metric tons of rare-earth oxide (REO) equivalent)

4.3 China's REE Deposits and Major Mining Regions

REE deposits are found in 17 provinces in China (see

[103] Data Source: (USGS, 2014). The USGS figure for China's rare earth mine production (100000 metric tons of REO equivalent) is larger than the official Chinese MLR figure for rare earth mine production (80423 metric tons of REO equivalent). It is unclear why there is a discrepancy between the two figures. To keep the same data source for comparison, this graph uses all figures from the USGS.

Table 1 for a breakdown of estimated amount of various types of deposits by provinces). The Baiyun-Ebo deposit in Baotou, Inner Mongolia in North China is the world's largest REE deposit and currently the largest source in terms of production volume. The ion-adsorption clay deposits in Gannan-Yuebei region bordering Guangdong Province, Jiangxi Province and Fujian Province in South China is the world's second largest production source of REEs in terms of production volume, and currently the world's only active HREE production site. There are also concentrated LREE deposits in other provinces, notably the Liangshanzhou deposit in Sichuan Province and the Weishan deposit in Shandong Province, but their amount of deposit and production is far less than the Baiyun-ebo deposit.

Table 1 REE Deposit Information by Province in China[104]

Province	Deposit Estimation (unit: 10000 ton)					
	Total	HREEs		LREEs		
		REOs	xenotime	REOs	mixed REOs	monazite
Inner Mongolia	8234.04				8234.04	
Guizhou	144.6				144.6	
Hubei	126.04	3		121.51		1.53
Sichuan	103.1	0.03		103.07		
Guangdong	64.64	18.69	3.08	31.89		10.98
Jiangxi	39.55	16.49	1.06	21.18		0.82
Hunan	36.61		0.04	10.56		26.01
Qinghai	34.61			34.61		
Shaanxi	26.78				26.78	
Guangxi	22.78		3.56	14.25		4.97
Shandong	9.91			9.91		
Yunnan	3.74		0.29	1.18		2.27
Henan	3.3			3.3		
Gansu	2.3				2.3	
Fujian	2.07	0.14	0.03	1.59		0.31
Hainan	1.21					1.21
Jilin	0.23		0.01			0.22
Total	8855.51	38.35	8.07	353.05	8407.72	48.32

[104] Data Source: (PRC Ministry of Land and Resources, 2000a). Provinces with active mining production are highlighted.

There has been debate among industry experts regarding the estimation of REE reserves in China. Liu Yujiu, Former Chief of the PRC State Council Rare Earths Expert Team (国务院稀土专家组), estimated in 2007 that based on the rate of extraction and usage data in 2002, the three major types of deposits in China could last only approximately 20-40 years (see Table 2). (Liu, 2007) Yet according to Meng Qingjiang, Vice Secretary of Jiangxi Rare Earth Research Society, the current official deposit statistics are from the Mining Deposit Survey conducted by then Ministry of Land and Minerals in 1985, and there has not been any updated national-level geological survey of rare earth mineral deposits despite of improvements in ore extraction technologies or economic feasibility of mining in China. (Guan, 2011) The Association of Rare Earth Industry of Jiangxi Province conducted preliminary survey of the ion-adsorption deposits in South China. The survey found significant amounts of reserves in Guangdong Province and Guangxi Province, but the actual amount of all reserves or proven reserves[105] could not be obtained without further exploration. (Guan, 2011)

[105] Proven reserves, also known as "proved reserves", is a metric used in mining sectors to refer to the amount of resources that can be recovered from the deposit with a reasonable level of certainty. It is often quoted by companies to demonstrate the amount of deposits available for extraction in short-term and medium-term projects.

Table 2 Utilization Ratio and Service Lifetime of REE deposits in 2002

Mineral Deposits	Resource Utilization Ratio	Service lifetime from 2002
Baiyun-ebo deposit in Baotou	8-10%	<37 years
Ion-adsorption deposits in South China	27.6-75%	<17 years
Liangshanzhou deposits in Sichuan Province	33-42%	<27 years

This thesis focuses on the two primary mining regions; the Baiyun-Ebo region in North China and the Gannan-Yuebei region in South China (see Figure 8). These two regions have a long history of production since the 1960s and the 1970s. They differ in types of resources and local geographical conditions.

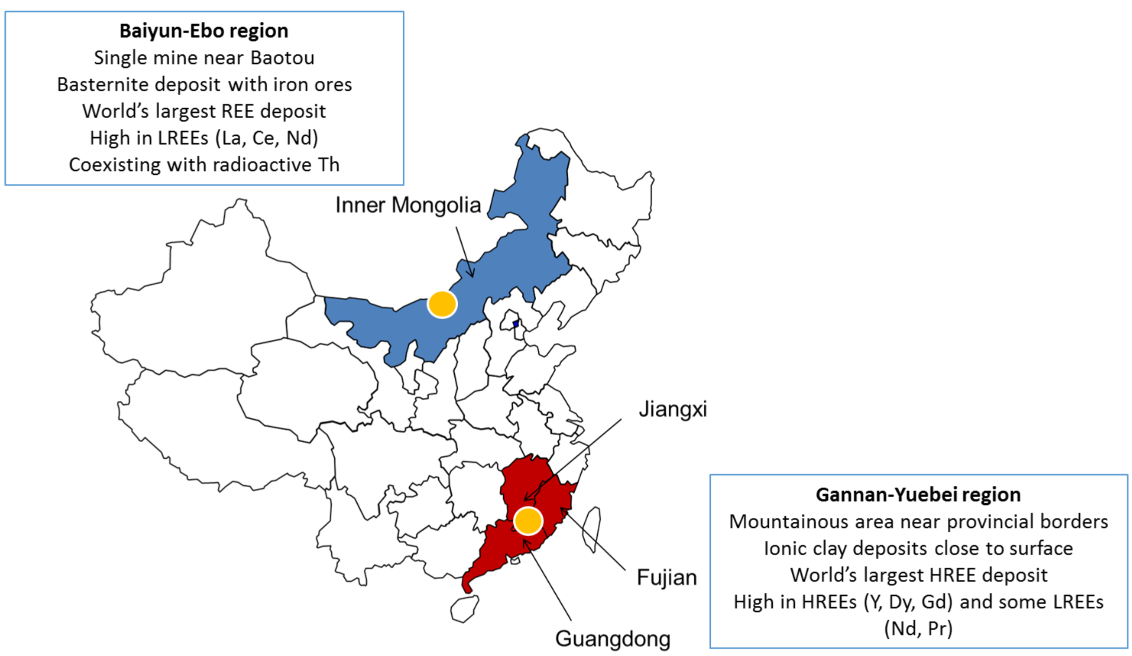

Figure 8 Baiyun-Ebo Bastnasite Deposits and Gannan-Yuebei Ion-adsorption Clay Deposits

The Baiyun-Ebo （白云鄂博） region in North China is located approximately 149 kilometers south of the center of Baotou (包头), Inner Mongolia Autonomous Region (内蒙古自治区) in North China. The prefecture-level city Baotou is nicknamed “Rare Earth Capital of the North”. The Baiyun-Ebo mine produces primarily iron ores, and REEs are produced as by-products from iron ore extraction. The REE deposits are bastnasite and monazite deposits (coexisting in the ratio of 6:4) with high concentration of **light rare earth elements (LREEs)**. The relative distribution of REEs in the ore is about 48% Cerium Oxide, 27% Lanthanum Oxide, 17% Neodymium Oxide and about 9% of other rare earth oxides[106]. The mining region is located on the Ulanqab Prairie.

The Gannan-Yuebei （赣南粤北） region in South China is located along the borders of Jiangxi Province (江西省), Guangdong Province (广东省) and Fujian Province (福建省) in South China. The prefecture-level city Ganzhou, a mining prefecture in Jiangxi Province, is nicknamed “Rare Earth Capital of the South”. In comparison to the LREE-rich Baiyun-Ebo mine, the Gannan-Yuebei region has ion-adsorption-clay deposits rich in **heavy rare earth elements (HREEs)**. For instance, the relative distribution of REEs in the ore from Longnan County, Ganzhou is about 64% Yttrium Oxide, about 7% Dysprosium Oxide, about 6% Gadolinium Oxide, about 4% Erbium Oxide, about 3% Neodymium Oxide, about 3% Ytterbium Oxide, about 2% Samarium Oxide, about 2% Lanthanum Oxide and about 1% Samarium Oxide. The relative distribution of REEs in the ore from another major mining county, Xunwu

[106] Data Source: China Rare Earth Net (http://www.cre.net). China Rare Earth Net is the official online database for rare earth industry sponsored by the State Rare Earth Office and the Baotou Research Institute of Rare Earths.

County, Ganzhou is about 30% Neodymium Oxide, about 30% Lanthanum Oxide, about 10% Yttrium Oxide, about 7% Cerium Oxide, about 7% Praseodymium Oxide, about 6% Samarium Oxide and about 2% Dysprosium Oxide[107]. Ion-adsorption rare earth deposits (离子吸附型稀土矿) occur in a weathered profile; therefore, these deposits can be easily mined by open pit methods, and thus they can be processed more easily. Unlike Baiyun-Ebo region which is part of a prairie, deposits are spread out in the mountainous areas belonging to seven prefecture-level cities along the provincial borders.

4.4 Non-Chinese Supply of REEs

This section analyzes non-Chinese REE projects and the barriers to develop a non-China supply chain. Because of the considerable capital costs, technological intensity, expensive and extensive regulatory hurdles, strong technical workforce requirement, environmental concerns and possible community/social backlash over mining, these non-Chinese projects can take a long time from deposit discovery to full commercialization. Existing non-Chinese junior mining projects have a low probability of replacing China's dominance in the global market in the near future.

4.4.1 Overview of Existing Non-Chinese REE Projects

By July 2014 there were 51 REE projects beyond the initial exploration stage in 16 different countries (Table 3 presents relevant deposit information for non-Chinese REE projects). This number of junior REE projects is unlikely to grow and could be massively reduced in the next few years. Investor interests in junior mining projects have significantly declined after the skyrocketing REE prices returned to prior-2010 levels in 2013, leading to diminished availability of capital. The lack of REE processing capacity

[107] Data Source: China Rare Earth Net (http://www.cre.net).

(hence lack of immediate demand for upstream mining products) outside of China also makes it difficult for junior projects to find long-term non-Chinese buyers. (Castilloux, 2013)

As the current largest producer of both LREEs and HREEs in the world, China is very likely to retain its dominating position in the near future. Major non-Chinese mining companies such as Molycorp in the U.S.[108] and Lynas in Australia/Malaysia[109] are now facing financial hurdles to continue production. Even if they can remain financially afloat, they will still mainly supply Lanthanum, Cerium and Neodymium. The relative distribution of REEs in ore from the Mountain Pass mine in the U.S. is about 50% Cerium Oxide, about 32% Lanthanum Oxide, about 12% Neodymium Oxide and about 6% other rare earth oxides[110]. The relative distribution of REEs in ore from Mount Weld mine in western Australia is about 46% Cerium Oxide, about 24% Lanthanum Oxide, about 17% Neodymium Oxide, about 5% Praseodymium Oxide and about 8% other rare earth oxides[111]. Therefore, they will not substantially help to alleviate the potential risk of supply of Yttrium and HREEs such as Terbium or Dysprosium. Non-Chinese HREE junior miners are mostly in exploration stage and face significant hurdles (see the next

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[108] U.S.-based Molycorp began production at its Mountain Pass mine in California in 2013 and anticipates production at full capacity (19,050 metric tons) in 2014. Molycorp also operates a separation plant at Mountain Pass, CA, and sells rare earth concentrates and refined products from newly mined and previously mined above-ground stocks. As of August 2015 Molycorp has filed for bankruptcy and is likely to discontinue its production.

[109] Lynas controls the Mount Weld mine in Western Australia, and a processing plant in Malaysia to process the ores from the Mount Weld mine. Lynas struggled with weak financial footing and announced in August 2015 that it is open to a takeover offer. (Roddan, 2015)

[110] Data Source: China Rare Earth Net (http://www.cre.net).

[111] Data Source: China Rare Earth Net (http://www.cre.net).

sub-section) in commercialization. A secure supply of the less-abundant, more-critical HREEs outside of China is still yet to come into full operation.

Table 3 Advanced REE Projects in the World (excluding China and India) [112]

Project	Country	Owner Company	Major Element	Estimated First Production Year
Aksu Diamas	Turkey	AMR Minerals Metal Inc.	La, Ce	N/A
Araxá	Brazil	MBAC Fertilizer Corp.	La, Ce	N/A
Ashram Main	Canada	Commerce Resources Corp.	La, Ce, Nd	N/A
Ashram MHREO	Canada	Commerce Resources Corp.	La, Ce, Nd	N/A
Bear Lodge (Bull Hill Zone)	US	Rare Element Resources Ltd.	La, Ce, Nd	2016
Bokan (Dotson / I & L Zones)	US	Ucore Rare Metals Inc	La, Ce, Nd, Y	N/A
Browns Range	Australia	Northern Minerals Limited	Y	N/A
Buckton	Canada	DNI Metals Inc.	Ce	N/A

[112] Data source: TMR Advanced Rare-Earth Project Index (http://www.techmetalsresearch.com/metrics-indices/tmr-advanced-rare-earth-projects-index/) which publishes a complete list of non-China REE projects.

Table 3 (continued)

Buckton South	Canada	DNI Metals Inc.	Ce	N/A
Charley Creek (J.V.)	Australia	Crossland Strategic Metals Ltd. & Pancontinental Uranium Corporation	Ce	N/A
Clay-Howells	Canada	Rare Earth Metals Inc.	La, Ce, Nd	N/A
Cummins Range	Australia	Navigator Resources Limited & Kimberley Rare Earths Limited	La, Ce, Nd	N/A
Dubbo Zirconia Project	Australia	Alkane Resources Ltd.	La, Ce, Nd, Y	N/A
Eco Ridge	Canada	Pele Mountain Resources Inc.	La, Ce, Nd	N/A
Elliott Lake Teasdale	Canada	Appia Energy Corp.	La, Ce, Nd	N/A
Foxtrot	Canada	Search Minerals Inc.	La, Ce, Nd, Y	N/A
Glenover (J.V.)	South Africa	Galileo Resources PLC & Fer-Min-Ore (Pty) Ltd.	La, Ce, Nd	N/A
Grande-Vallee	Canada	Orbite Aluminae Inc.	Ce	N/A
Hastings	Australia	Hastings Rare Metals Limited	Y	N/A

Table 3 (continued)

Hoidas Lake	Canada	Great Western Minerals Group Ltd.	La, Ce, Nd	N/A
Kangankunde	Malawi	Lynas Corporation Ltd.	La, Ce, Nd	N/A
Kipawa (J.V.)	Canada	Matamec Explorations Inc.	La, Ce, Nd, Y	N/A
Kutessay II	Kyrgyzstan	Stans Energy Corp.	La, Ce, Y	N/A
Kvanefjeld	Greenland	Greenland Minerals and Energy Ltd.	La, Ce, Nd, Y	N/A
La Paz	US	Australian American Mining Corporation Ltd.	La, Ce, Nd, Y	N/A
Laverge-Springer	Canada	Canada Rare Earth Corp.	La, Ce, Nd	N/A
Lofdal	Namibia	Namibia Rare Earths Inc.	La, Ce	N/A
Milo	Australia	GBM Resources Ltd.	La, Ce	N/A
Montviel (Core Zone)	Canada	Geomega Resources Inc.	La, Ce, Nd	N/A
Mount Weld CLD	Australia	Lynas Corporation Ltd.	La, Ce, Nd	2012
Mount Weld Duncan Deposit	Australia	Lynas Corporation Ltd.	La, Ce, Nd	N/A

Table 3 (continued)

Mountain Pass	US	Molycorp Inc.	La, Ce, Nd	2012
Mrima Hill High Grade	Kenya	Pacific Wildcat Resources Corp.	La, Ce, Nd	N/A
Mrima Hill Main	Kenya	Pacific Wildcat Resources Corp.	La, Ce	N/A
Nechalacho Basal	Canada	Avalon Rare Metals Inc.	La, Ce, Nd	2016
Nechalacho Upper	Canada	Avalon Rare Metals Inc.	La, Ce, Nd	2016
Ngualla	Tanzania	Peak Resources Ltd.	La, Ce, Nd	N/A
Niobec	Canada	IAMGOLD Corporation	La, Ce, Nd	N/A
Nolans	Australia	Arafura Resources Ltd.	La, Ce, Nd	N/A
Norra Karr	Sweden	Tasman Metals Ltd.	La, Ce, Nd, Y	N/A
Olserum	Sweden	Tasman Metals Ltd.	La, Ce, Nd, Y	N/A
Round Top	USA	Texas Rare Earth Resources Corp.	Y	N/A
Sarfartoq (ST1 Zone)	Greenland	Hudson Resources Inc.	La, Ce, Nd	N/A
Serra Verde	Brazil	Mining Ventures Brasil Ltda.	La, Ce, Y	N/A
Songwe	Malawi	Mkango Resources Ltd.	La, Ce, Nd	N/A

Table 3 (continued)

Sorensen	Greenland	Greenland Minerals and Energy Ltd.	La, Ce, Nd, Y	N/A
Steenkampskraal	South Africa	Great Western Minerals Group Ltd.	La, Ce, Nd	N/A
Storkwitz	Germany	Seltenerden Storkwitz AG	La, Ce	N/A
Strange Lake Enriched	Canada	Quest Rare Minerals Ltd.	La, Ce, Nd, Y	N/A
Strange Lake Granite	Canada	Quest Rare Minerals Ltd.	La, Ce, Nd, Y	N/A
TANBREEZ	Greenland	Rimbal Pty Ltd.	La, Ce, Y	N/A
Tantalus	Madagascar	Tantalus Rare Earths AG	La, Ce, Nd, Y	N/A
Two Tom	Canada	Rare Earth Metals Inc.	La, Ce, Nd	N/A
Wigu Hill Twiga	Tanzania	Montero Mining and Exploration Ltd.	La, Ce, Nd	N/A
Xiluvo	Mozambique	Southern Crown Resources Ltd.	La, Ce, Nd	N/A
Zandkopsdrift (J.V.)	South Africa	Frontier Rare Earths Ltd. & Korea Resources Corp.	La, Ce, Nd	2016
Zone 3	Greenland	Greenland Minerals and Energy Ltd.	La, Ce, Nd, Y	N/A

4.4.2 Barriers to Project Success

4.4.2.1 Resource Endowment

One of the most commonly cited reasons for the inherent risk of natural resources supply is their nature of scarcity and uneven distribution amongst countries. REEs as a whole are not "rare", even though a specific rare earth element may concentrate within specific regions rather than spread out evenly across the world. For instance, Dysprosium, considered to be the most critical element in the short term by the U.S. DOE (2010, 2011a), has a disproportionately large deposit in Southeast China (Hoenderdaal, 2013) in the global deposit estimates.

A related issue in assessing the resource endowment of junior miners is the lack of a single accepted global standard for estimating resource reserves and identifying the potential value of supply for investors. (Hatch, 2012) Existing standards for mining companies to use for reporting mineral reserves include NI 43-101 standard (Canada)[113], the JORC code (Australia)[114], the SEC Guide 7 standard (U.S.)[115] and the SAMREC code (South Africa)[116]. The NI 43-101 Standard is an information disclosure code developed by the Canadian Securities Authorities; companies trading on the Toronto Stock

[113] Details of the NI 43-101 standard can be found at http://www.cim.org/committees/NI_43-101_Dec_30.pdf (accessed August 8, 2014). Some companies listed on the Australian Stock Exchange use the NI 43-101 Standard to provide more detailed technical information regarding their resources. The National Instrument 43-101 (NI 43-101) requires substantially more technical disclosure to investors than JORC Code.

[114] Details of the JORC code can be found at http://www.jorc.org/.

[115] The SEC Guide 7 Standards have been criticized as less informative in classifying mineral resource potential for investors to assess deposit values (Hatch, 2012). Details of the standards can be found at http://www.cim.org/standards/documents/Block474_Doc32.pdf.

[116] Details of the SAMREC code can be found at http://www.cim.org/standards/documents/Block473_Doc92.pdf.

Exchange are required to use the NI 43-101 standards when publishing their results. The JORC code is released by the Australian Joint Reserves Committee (JORC); companies trading on the Australian Stock Exchange use the JORC code when releasing information. The SEC Guide 7 Standards are developed by the United States Securities and Exchange Commission (SEC) and contain basic principles in mining disclosure policy. The SAMREC code (South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves) are developed by the South African Mineral Resource Committee Working Group and set out minimum standards, recommendations and guidelines for Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves in South Africa. Different standards have different classification techniques for reporting mining reserves, therefore they require different level of technical information disclosure in releasing project information. If one uses mining deposit information derived from different standards, incorrect comparison of the resource endowment would occur.

4.4.2.2 Fiscal Constraints

Nascent projects of REE mining are very likely to fail without significant financial backing from private investors or government support. (Long et al, 2010) Rare earth mining projects are capital intensive, with average capital costs projected to be greater than $40 per kilogram of annual capacity. (Kingsnorth, 2010) The discovery of a rare earth deposit must be proved by extensive trenching, drilling and sampling, leading to huge front capital cost that must be paid by the mining firm and the investors. (Long et al, 2010) The concentration of rare earth elements in the deposits is often low, thus exploration will often only proceed on the basis of favorable results. This significant front capital cost can sometimes be reduced depending on the properties of the specific deposit. When the rare earth elements co-exist with other valuable metals, mine operators can extract rare earths as by-products from producing major valuable metals from the same deposit. For instance, the Baotou Steel Rare Earth (Group) Hi Tech Co. in Inner Mongolia, China, the world's largest rare earth producer, produces primarily iron ores and rare earth elements as by-products[117].

4.4.2.3 Regulatory Barrier

Mining projects in general require extensive, expensive and time-consuming processes of governmental approval that increases project uncertainty and deters investors. For instance, approval of mining permits in the U.S. typically requires "an approved plan of operations, a positive environmental impact study, and some kind of final permission by a government agency. If external financing is required, an independent due diligence study will verify the results of the feasibility study." (Long et al, 2010) Even after financial and regulatory approvals are granted, detailed engineering design of construction and testing of mining operation needs to be conducted within a ramp-up period, until full commercial production at the planned output rate is achieved. Therefore, a mining company will have to spend significant amounts of money to finance operation during the time lag before there is any revenue from mineral sales. Regulatory barriers remain fairly high for junior miners in most countries. Long et al (2010) found that on average a mining company in major non-Chinese mineral supplier countries needs to go through one or two decades of exploration and application for approval before

[117] The steel produced from the mined iron were first found to be "contaminated" with rare earth elements, and then Baotou Steel started the rare earth exploration, and the production of REEs from the ashes left over by the iron purification process. (Long et al, 2010)

beginning commercial operation. MIT Energy Initiative (2010) estimates that for a junior rare earth project specifically, it takes about 10-15 years to go into full commercial operation from discovery. This rather long time lag of profit return makes profit further unpredictable at the time of discovery and deters investors from investing in junior projects.

4.4.2.4 Technology Barrier

The operation of a successful rare earth mining project relies on skilled technical workforce, which is largely absent outside of China. There has been a steady decrease in the number and the education level of non-Chinese trained scientists and engineers qualified to work in rare earth mining and manufacturing industries (for instance, see Figure 9 for the decline of the U.S. workforce in the rare earth industry in the last three decades[118]). The former CEO of the American mining company Molycorp, Mark Smith once remarked that he has "17 engineers and scientists competing with over 6,000 scientists in China." (Jacoby and Jiang, 2010) In comparison, China has the world's largest number of research scientists with rare-earth expertise in its top research labs[119].

The lack of a strong non-Chinese technical workforce is not only found in REE mining but also smelting and further processing. Up till now no other country except China has large-scale processing facilities capable of processing commercial amount of HREEs. Even as non-China REE mines produce REE products, the primary products would mostly still need to be shipped to China to be further processed into intermediate products. A case to illustrate this concerns Molycorp's acquisition of Neo Materials in

[118] Data Source: Gschneidner (2011)

[119] For instance, Baotou Rare Earth Institute in Inner Mongolia is now the world's largest rare earth research organization.

2012. In order to build up the supply chain of "mine to magnets", U.S. mining company Molycorp acquired Neo Materials Technologies, parent company of Magnequench which has processing plants in Tianjin to gain access to processing and magnet producing capabilities currently located in China. (Areddy, 2012)

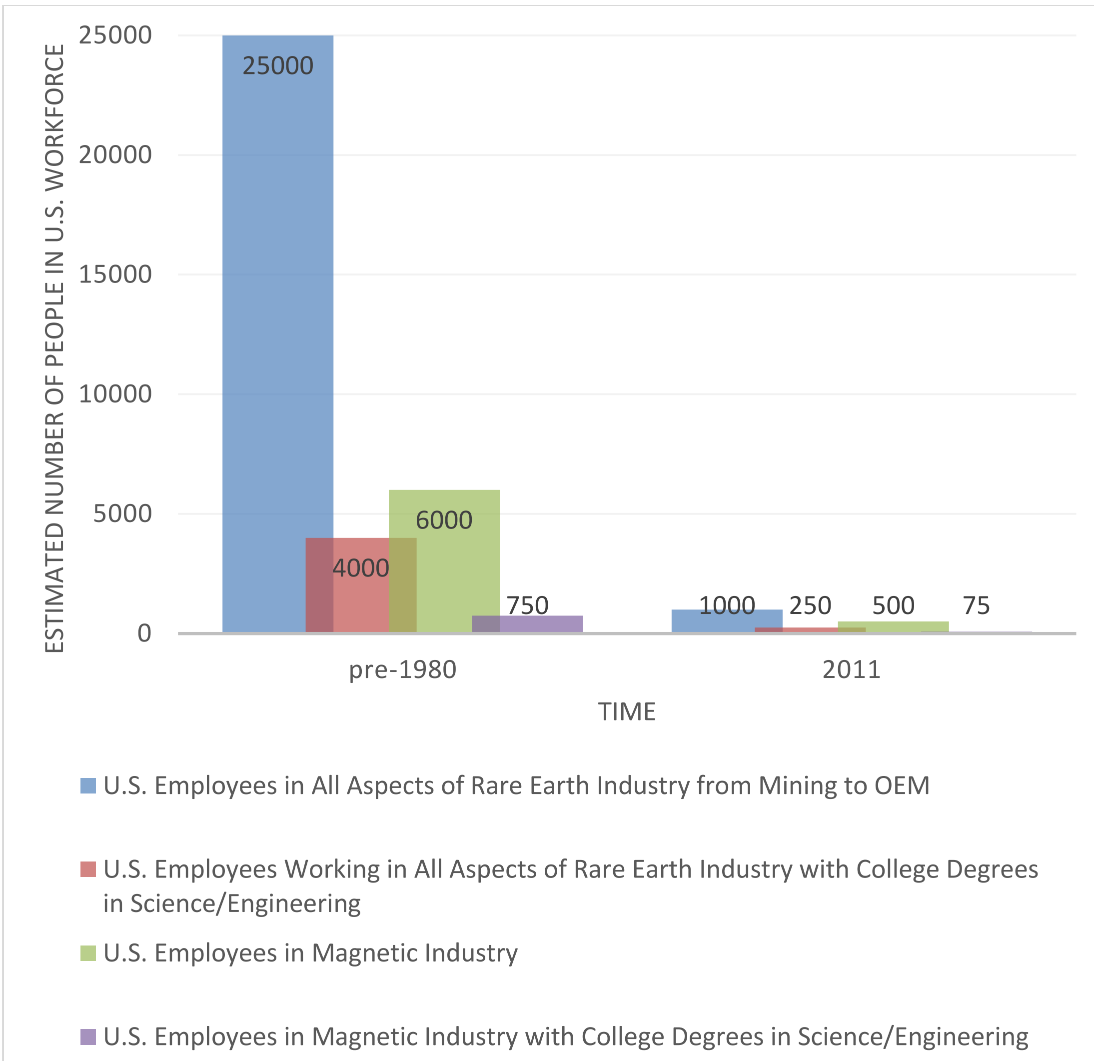

Figure 9 Decline of the U.S. Workforce in the Rare Earth Industry

<u>4.4.2.5 Environmental Concerns</u>

A significant source of risk for developing new REE supply is the environmental consequences of mining and the associated costs of treatments. Rare earth mining and smelting can produce significant amount of waste residue, polluted air and waste water. Depending on the deposit, significant amount of radioactive waste that can create irreversible damage to humans and ecological environment. The foremost environmental issue for mining projects concerns the ores themselves, which may contain radioactive materials posing great risk for exploration and production. Both monazite[120] and xenotime deposits can contain highly radioactive minerals such as uranium and thorium that needs to be properly treated[121]. Failure of radioactivity treatment can lead to irreversible contamination of the environment and forced suspension of operation. For instance, prior to 1988 xenotime from Malaysia was the largest source of yttrium in the world. Yet because xenotime in the Malaysian placer deposits contains strong radioactive minerals (on average 2% uranium and 0.7% thorium), the strong radioactivity led to environmental casualties, the failure of processing plants and the downturn of the Malaysian rare earth industry. (Yusoff & Latifah, 2002) Environmental danger is also present in smelting and further processing. Solutions concentrated in REEs are treated with solutions containing strong acid or strong base for separation and purification, producing toxic waste water, waste gas and solid waste concentrated with radioactive elements.

Concerns about radioactive and toxic wastes have effectively delayed or halted the progress of mining in a number of regions. For instance, upon hearing the news that a

[120] Because thorium is able to substitute for the REE in the monazite structure, radioactive byproducts including thorium and its daughter product uranium is a challenge to projects of monazite deposits.
[121] See Akademi Sains Malaysia (2011).

rare earth processing plant was to be built in Malaysia by Lynas, more than five thousand people joined a local rally against the project in fear of radioactive contamination in February 2012[122]. While Lynas Australia has started its operation since 2013, local protests persisted, which recently resulted in the arrest of several protestors[123].

4.4.2.6 Social Concerns

The environmental risks of mining and smelting often lead to protests from the local communities that wish the projects are "not in my backyard". Ineffective government regulation or communication can make the public suspicious about the operation of projects and the potential long-term consequences for the community. Labor rights abuse, lack of transparency in project operation, lack of oversight from company executives and corrupt local officials commonly found in developing countries further exacerbate public resentment and even cause closure of plants. For instance, a rare earth refinery in northern Perak state in Malaysia operated by the Mitsubishi of Japan was closed in 1992 after strong local protest which claimed that radioactive pollution from the plant caused birth defects and leukemia among residents. The now defunct plant has become one of the largest radioactive waste sites in Asia. (Bradsher, 2011)

Mining projects, by their nature of extracting raw materials, can also spark accusation of resource exploitation by the local indigenous community. If no downstream industries are present in the same mining region, primary products from mining are shipped outside for further processing instead of benefiting the local economy. This resentment is often more pronounced when the investors of rare earth projects are multinational corporations shipping the primary products for offshore manufacturing and

[122] See AFP (2012).
[123] See Harvey (2014).

selling high-priced end products back into the region. Local communities are quick to accuse the mining projects as new forms of "colonialism" or "Western imperialism". Recent remarks by Chinese critics in opposition to export of primary products[124] and remarks by Malaysian protestors in opposition to the Lynas project[125] have both echoed such accusations.

4.5 Global REE Demand

This section provides a brief overview of major applications of REEs and the trend of global demand. Table 4 presents an overview of the specific applications of the rare earth elements. The common applications include rechargeable batteries and permanent magnets (used in most modern technical applications), lighting (used in such applications as LED lights and CFL lights), flat screen displays (used in such application as color television screens, cellphone and laptop displays), industry catalysts (used in such procedures as petroleum refining and automobile emission reduction) and numerous medical applications. There are also important national security applications enabled by technologies utilizing REEs, such as solid-state lasers, jet fighter engines, antimissile defense, space-based satellites and communication systems. Figure 10 and Figure 11 present the share of global REE demand in different category of applications by volume and by value. As can be seen from both figures, magnets account for the largest demand for REEs both by volume and by value.

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[124] See for instance Wang (2012), a popular book in China that claims western countries exploit China's rare earth resources for their own benefit of developing high-tech consumer products and offensive weapons. Also see Chen (2012), an editorial published by the China Daily accusing western countries of hypocrisy of using China's cheap resources.

[125] See Lam (2012).

Future industry demand for the REEs may change depending on the advent of new technologies and the fluctuation of demand for current products. As more and more countries embark on the transition to alternative energy, there will be an estimated increase of more than 700% for Neodymium demand and more than 2600% for Dysprosium demand over the next 25 years if the present needs are representative of future needs. (Alonso et al, 2012) Specifically the U.S. Department of Energy (2011a) has identified Neodymium, Europium, Yttrium, Terbium and Dysprosium as elements in critical risk of short-term and medium-term supply necessary for the development of alternative energy technologies. The global REE demand is projected to rise to at least 160,000 tons annually by 2016[126].

Besides being the largest producer of REEs, China has also grown to be the major consumer of REEs in the world due to its dominance in producing rare earth smelting products such as rare earth alloys and magnets. China's demand now accounts for more than 60% of the world's REE demand, and it is expected to continue as such in global demand in the near future (see Figure 12).

[126] Source: IMCOA, from Long (2011).

Table 4 Key Applications of Rare Earth Elements[127]

		Major applications							
		Permanent Magnets	Electric vehicle battery	Phosphors and lighting	Catalysts	Glass& Ceramics (including lasers)	Metal alloys	Medical use	Nuclear energy
Light Rare Earth Elements (LREE)	Scandium (Sc)						X		
	Lanthanum (La)		X	X	X	X	X	X	
	Cerium (Ce)		X	X	X	X	X	X	
	Praseodymium (Pr)	X		X		X	X		
	Neodymium (Nd)	X				X	X	X	
	Promethium (Pm)								X
	Samarium (Sm)	X			X	X		X	
	Europium (Eu)			X		X		X	
	Gadolinium (Gd)			X		X	X	X	
Heavy Rare Earth Elements (HREE)	Yttrium (Y)			X	X	X	X	X	
	Terbium (Tb)	X		X		X			
	Dysprosium (Dy)	X				X			X
	Holmium (Ho)					X			X
	Erbium (Er)					X	X	X	X
	Thulium (Tm)							X	
	Ytterbium (Yb)					X			
	Lutetium (Lu)								

127 Source: Data compiled and expanded from APS & MRS (2011), Resnick Institute (2011), and U.S. Department of Energy (2011). Elements shaded in the green in the table are rare earth elements deemed in critical supply in both short term (0-5 years) and medium term (5-15 years), as defined by the U.S. Department of Energy (2010).

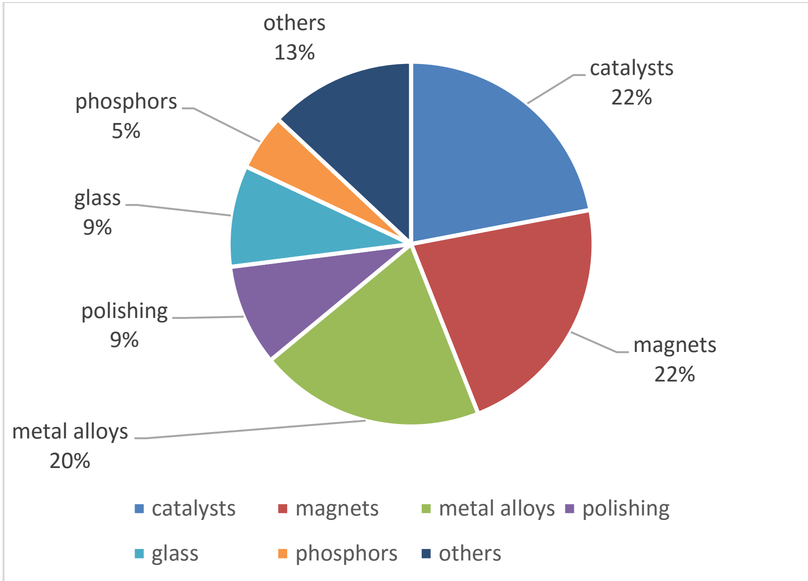

Figure 10 Major REE Demand in Applications by Volume[128]

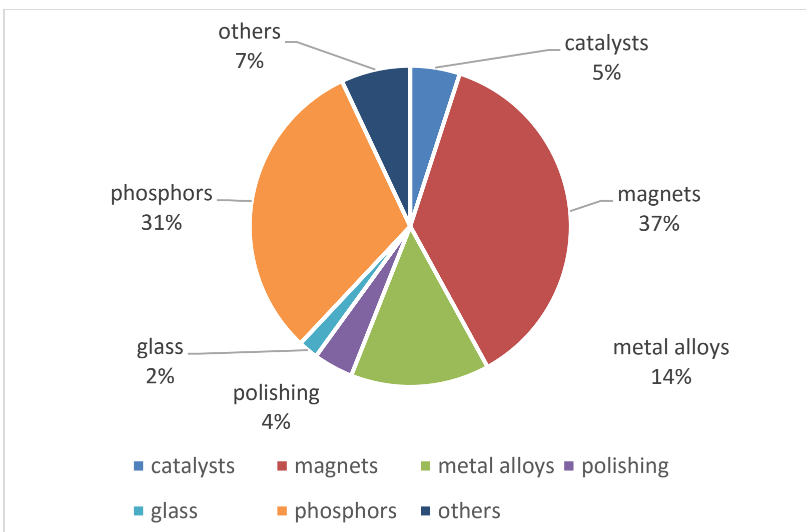

Figure 11 Major REE Demand in Applications by Value[129]

[128] Source: Industrial Minerals Company of Australia Pty Ltd. (IMCOA), from Long (2011).
[129] Source: IMCOA, from Long (2011).

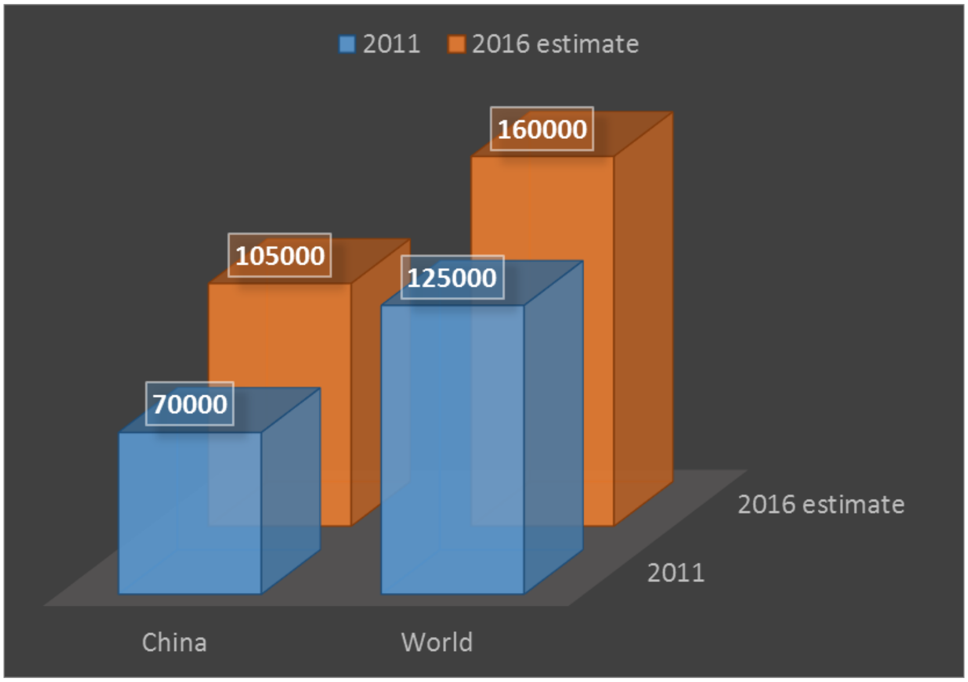

Figure 12 Global and Chinese REE Demand in 2011 and 2016 (estimate)[130]

4.6 Global REE Production Chain

This section focuses on the REE-enabled production chain in modern technologies, through analyzing examples of two alternative energy technologies that have important policy relevance and projected high future growth: wind power and electric/hybrid vehicles. In general, an REE-enabled production chain starts with REE deposits as raw materials and includes processes of mining, smelting, further chemical processing and compound manufacturing to become part of the final product. Take the production of most common applications in the rare earth industry, permanent magnets and metal alloys as an example. Primary ores (原矿) containing the REEs are mined (采矿) from underground. The ores then go through mineral dressing (选矿) process to become rare

[130] Source: IMCOA, from Humphries (2013).

earth concentrates (稀土精矿), which contain much higher purity of REEs than primary ores. The rare earth concentrates then go through unique, extensive smelting and separation (冶炼分离) processes to become basic products such as rare earth chlorides, or be further processed to achieve the ideal purity as intermediate rare earth products, including mixed rare earth metals, mixed rare earth oxides (REOs), individual REOs, rare earth metal alloys, etc. The rare earth products are then manufactured into specific REE-enabled components, such as NdFeB permanent magnets, Europium doped Yttrium Oxide phosphors, or Cerium Oxide polishing powder. The components are finally manufactured as parts into the final downstream products, such as headphones, automobiles, wind turbines, color TVs and Magnetic Resonance Imaging scanners. Figure 13 presents an illustration of the major industrial processes involving rare earth alloys as intermediate products. Usually the final downstream manufacturing process is not included as part of the rare earth industry. Downstream products at the end of the production chain are much more highly valued than upstream products at the start of the production chain. The market demand for these downstream products together constitute the demand for the upstream products.

Both wind power and electric/hybrid vehicles primarily employ permanent magnets (PM) containing REEs. Currently there are two types of rare earth magnet in production, Rare Earth Cobalt magnet and Rare Earth Iron Alloy magnet. The section focuses on the latter which is widely used. The Rare Earth Iron Alloy magnet is made of alloy with a composition ratio of two REE atoms, fourteen iron atoms and one boron atom. This is the most widely used type of rare earth magnet, and it has considerably strong magnetic properties (BH_{max} =200-400 kJ/m^3). The most widely used type of rare earth magnet is

Neodymium Iron Boron Alloy (NdFeB) magnet. NdFeB magnet contains primarily Neodymium, as well as small amounts of Dysprosium, Praseodymium and Terbium to adjust the magnetic functions under specific temperatures. There are two types of NdFeB magnets, sintered NdFeB magnets and bonded NdFeB magnets (industrial categorization is based on different production techniques). The former, Rare Earth Cobalt magnet is made of alloys with the approximate ratio of one rare earth atom with 5 Cobalt atoms. The REE is most commonly Samarium, but can also be other LREEs such as Praseodymium, Cerium, Neodymium, or a combination of them. This type of REE-Co (e.g. SmCo) magnet has the advantage of maintaining magnetic properties under very high temperatures (T_c=700-800°C), yet it has weaker magnetic power than Rare Earth Iron Alloy magnet and is much higher priced (usually priced over 60 times higher than Rare Earth Iron Alloy Magnet due to the high price of rare metals including Cobalt). Rare earth Cobalt magnet is found usually in applications which require extremely high working temperature and has limited utilization in energy technologies.

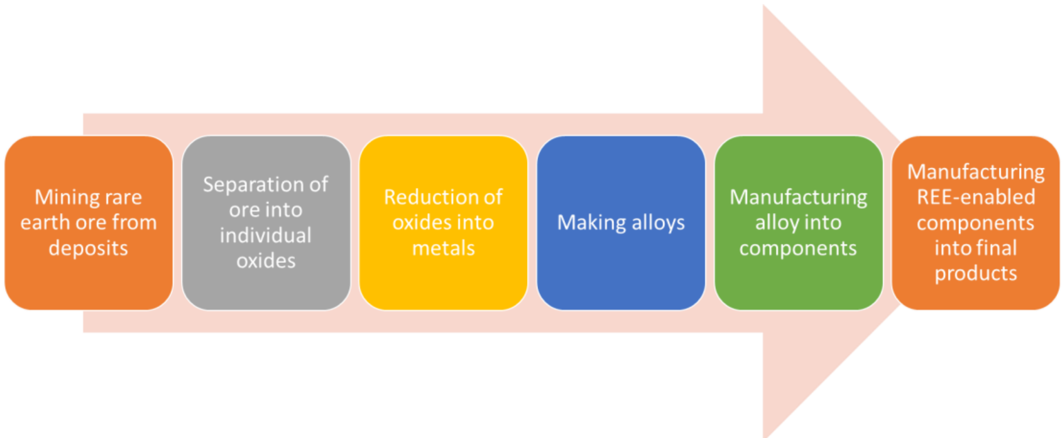

Figure 13 Example of a Production Chain Involving Rare Earth Metal Alloys[131]

4.6.1 REE Production Chain in Wind Power

Wind power produces consistent electricity with no fuel consumption and no air pollutant emission. It has been recognized as a key contributor to global renewable energy development in both short-term and long-term. (REN21, 2013) The total cumulative installed capacity of wind power worldwide has been steadily increasing at about 15% annually and has already reached 318 GW by 2013. (GWEC, 2014)

REE-enabled wind turbines have superior performance compared to other generator designs used in wind turbine production. Among the different kinds of generator systems used in wind turbines, direct-drive synchronous generators produce electricity currents at a relatively lower rotation speed, require lower maintenance and have consistently higher performance (see Figure 14). Among the direct-drive generator designs, direct-drive permanent magnet generators (DDPMG) have the highest energy yield. (Polinder et al., 2006)

[131] Source: (GAO, 2010)

REEs are manufactured into sintered NdFeB magnets and then into wind turbines through a series of technical processes (shown in Figure 15). Sintered NdFeB magnets containing Neodymium, Praseodymium and small amounts of Dysprosium are usually used in the production of DDPMG; this is because wind turbines operate under rough external conditions, and sintered NdFeB magnets have higher resistance to corrosion than bonded NdFeB magnets. For a typical DDPMG, roughly 600 kilograms of permanent magnet is required per MW generation of electricity. (U.S. DOE, 2011b)

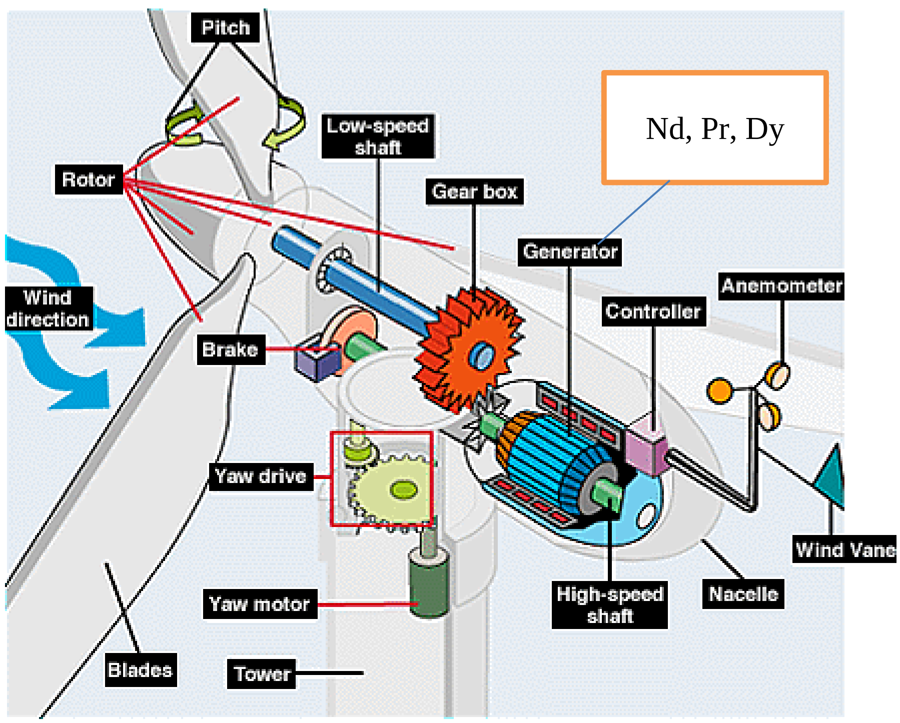

Figure 14 Rare Earth Materials in Wind Turbines[132]

[132] Public domain image available at http://www1.eere.energy.gov/windandhydro/wind_how.html

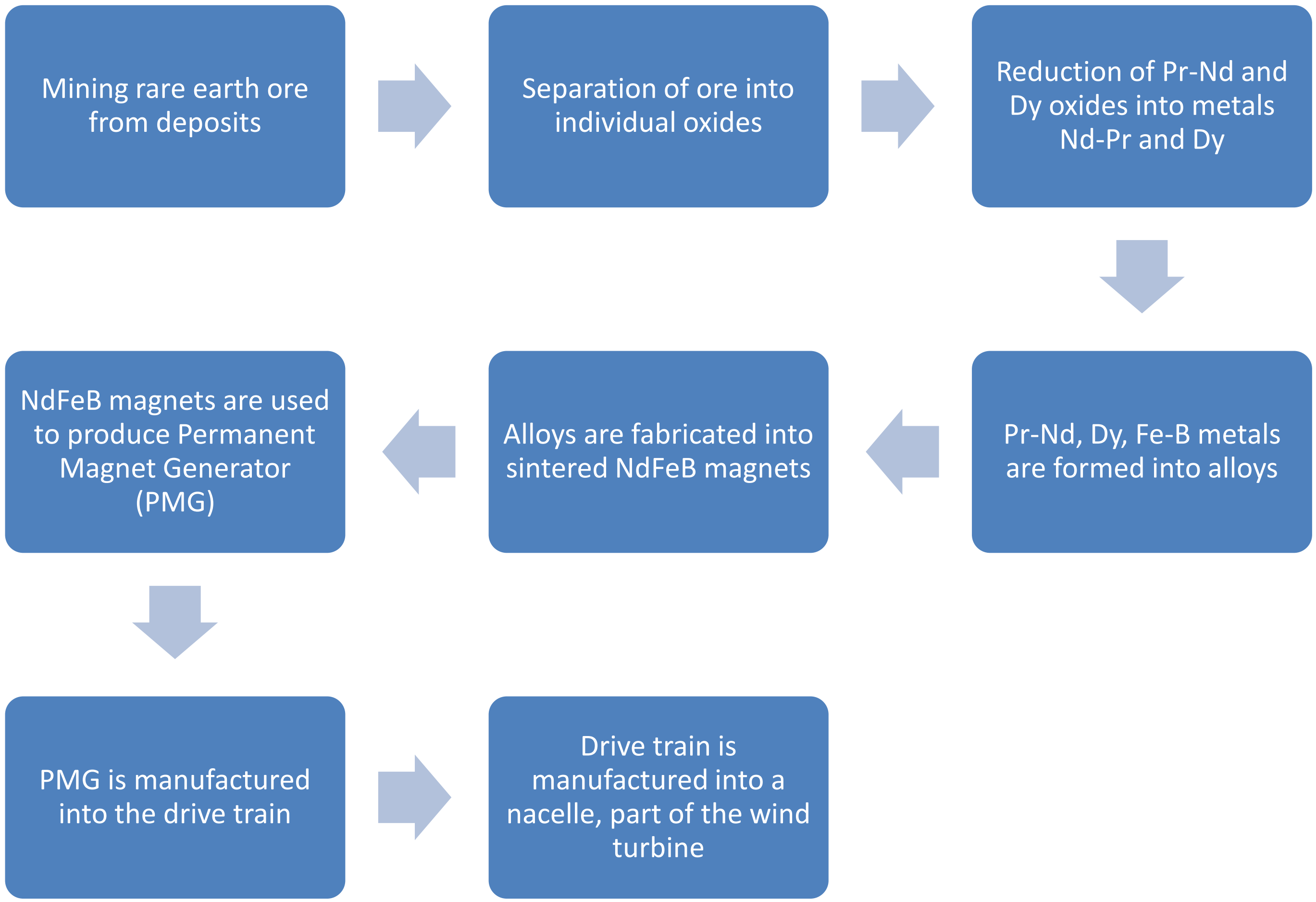

Figure 15 REE Material Flow in Wind Turbine Production

4.6.2 REE Production Chain in electric/hybrid vehicles

REEs are indispensable to the production of both conventionally powered vehicles and alternative energy vehicles. The use of REE-enabled permanent magnets allows greater performance to be obtained from a smaller, lighter motor. As the public demands lighter, more efficient cars, the use of micro-drive motors containing REE permanent magnets in vehicles has become prevalent. For instance, a conventional vehicle contains in various parts (including glass, motor, car seats, cooling fan, etc.) 20-100 micro-drive motors which utilize NdFeB magnets. A conventional vehicle contains REEs of approximately 0.44 kilograms. (Ford Motor Company, 2014)

Compared to conventional vehicles, electric/hybrid vehicles produce zero to low emissions of Greenhouse Gases (GHG) and air pollutants and very low noise, making them ideal choices to improving environment protection and energy conservation in transportation in modern metropolitan areas. Specifically electric vehicles are expected to rise significantly in adoption in the next few years: government targets around the world altogether call for an estimated 20 million electric vehicles in operation by 2020, a significant increase from the approximately 40,000 vehicles in use by the end of 2012. (IEA 2013a)

REE-enabled technologies are critical for electric/hybrid vehicles (See Figure 17 for an illustration of the rare earth material flow in the electric vehicle production). Figure 16 shows various REE-enabled applications used in producing the Toyota Prius, a model of hybrid electric vehicle currently on the market. More electrified vehicles need higher amounts of REEs. A typical HEV with a nickel-metal-hydride battery uses approximately 4.5 kg of REEs. A typical HEV with lithium-ion batteries contain approximately 1 kg of

REEs. (Ford Motor Company, 2014) The production of the electric motor-generator for one hybrid/electric alone needs about 1-3 kilograms of NdFeB magnets. Among them, the electric motor in an electric/hybrid vehicle is used to convert electricity into mechanical motion to propel the vehicle, as well as to convert energy from the engine or wheel rotation into electricity to be stored in the battery. To ensure stable and strong performance, the motor needs to be light-weight and energy efficient. Therefore, REE-permanent-magnet motor is the ideal choice.

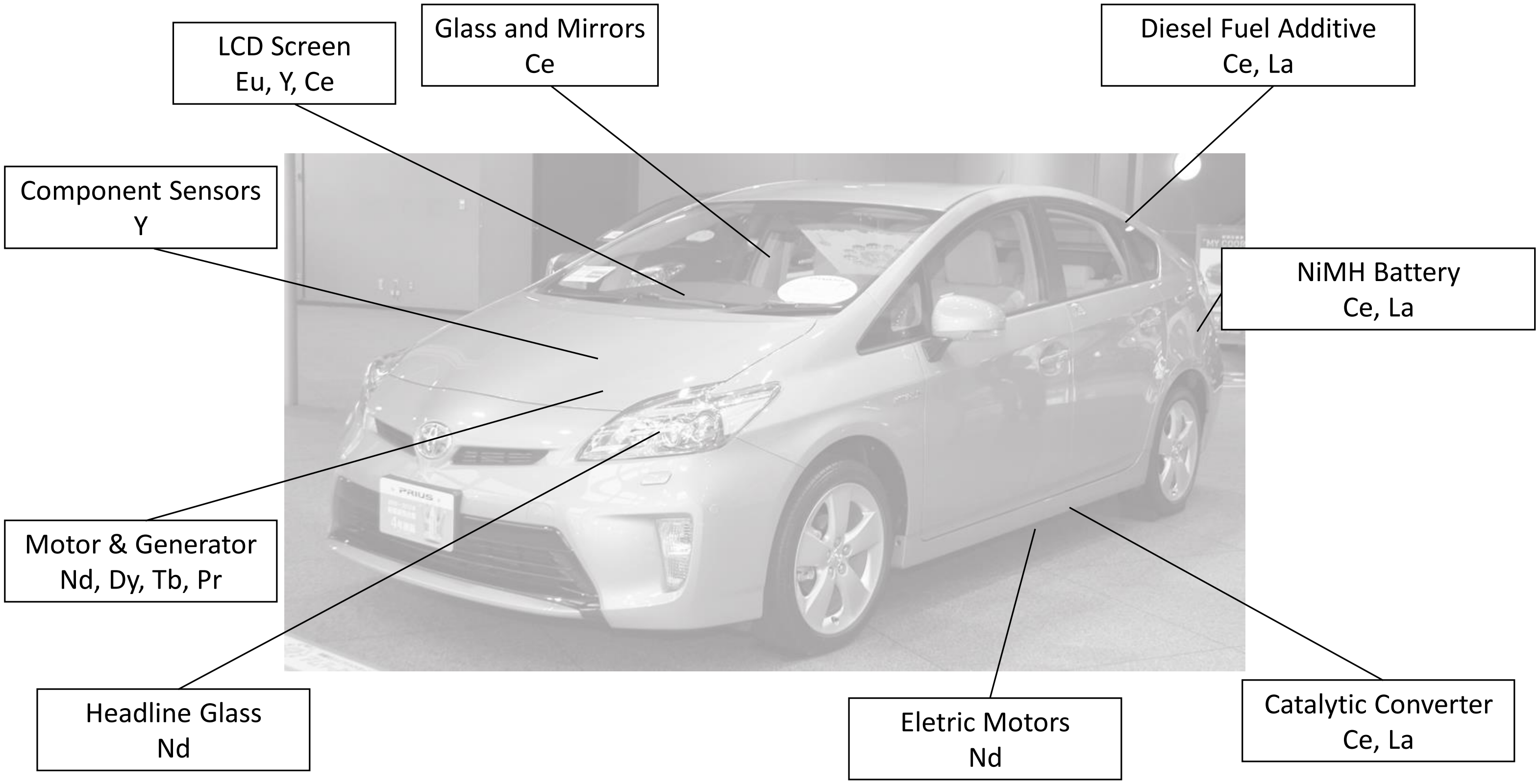

Figure 16 Rare Earth Materials in the Toyota Prius[133]

[133] Source: (U.S. House Committee on Natural Resources, 2010)

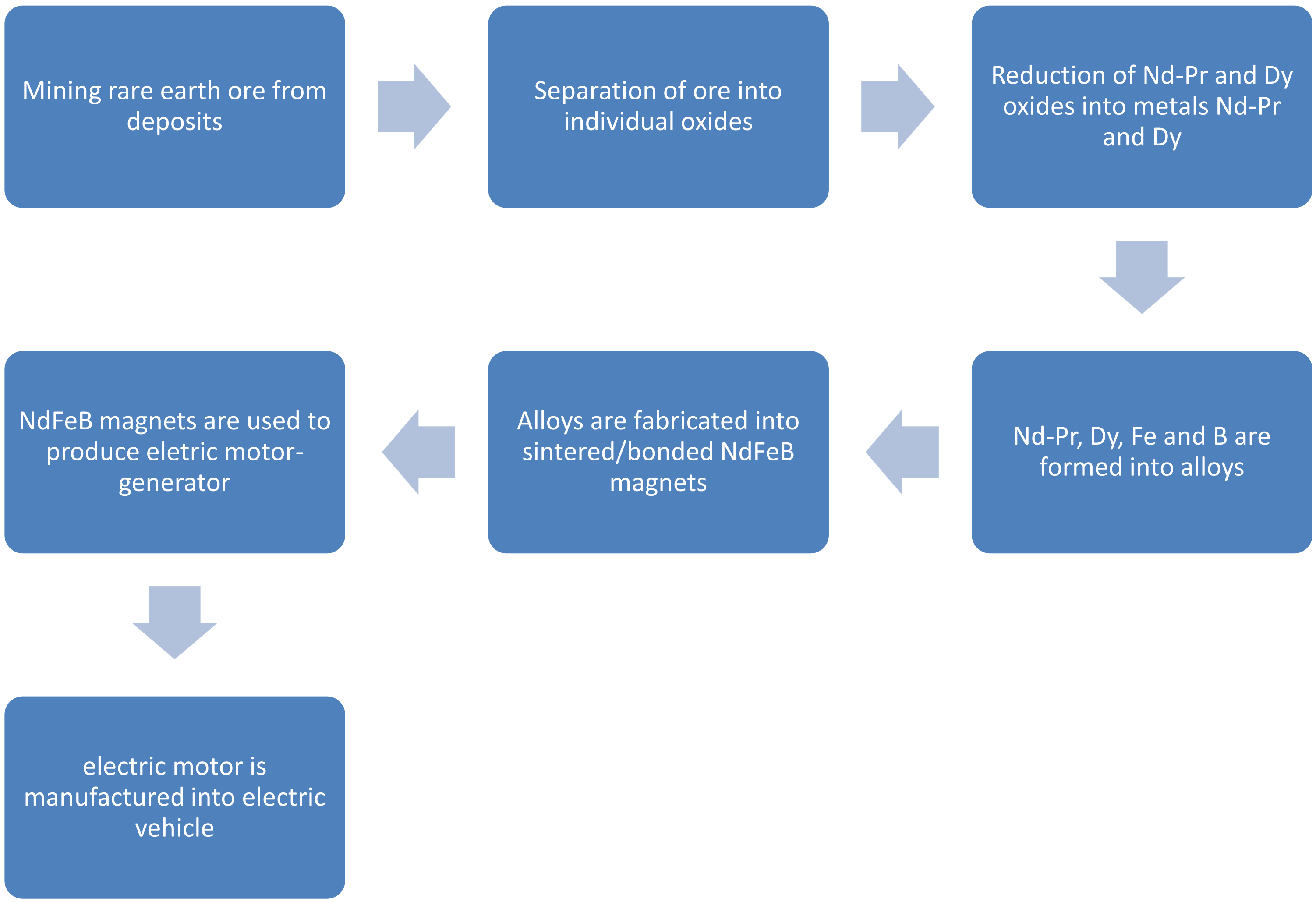

Figure 17 REE Material Flow in Electric Vehicle Production

4.6.3 How REE Market Conditions Affect the REE Production Chain

The fluctuation of the price of primary rare earth products in the past few years has led to strong fluctuation in the permanent magnet market. When the prices of REOs are sufficiently high to justify the switch to less effective technologies, the end users would sacrifice performance for better price. Reregulation policy changes led by the Chinese central government since 2009 led to artificial changes in supply, speculative buying and price fluctuations on the REO market in 2009-2013 (see Figure 18 and Figure 19 for the price fluctuation of Praseodymium-Neodymium Oxide and Dysprosium Oxide, primarily used for the production of permanent magnets). Average REO prices reached record high in 2011 amid speculations of supply shortage, but then dropped to pre-2010 level in 2013. Ferrite permanent magnet, the widely used magnetic technology before the adoption of REE permanent magnets, is now mainly used in applications which do not require light weight[134] or compact size[135]. The price of the REE-enabled permanent magnets became much higher than the less suitable alternative, ferrite permanent magnets in 2011. As a result, the REE-enabled permanent magnets suffered a large decline in purchase, and less than 60% of the Chinese NdFeB permanent magnet producers were in full operation in 2011 and 2012. (Zhou, 2013)

[134] Ferrite magnet weighs on the order of 6 times larger than REE magnets with same magnetic functions.
[135] Ferrite magnet's size is on the order of 10 times larger than the REE magnet with same magnetic functions.

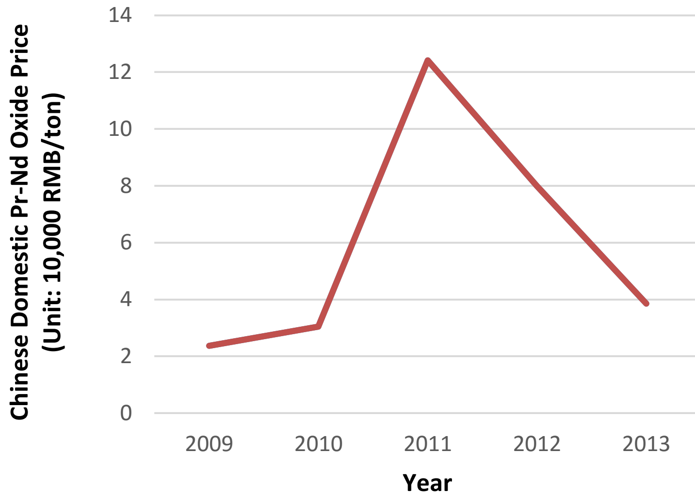

Figure 18 Chinese Domestic Pr-Nd Oxide Price Fluctuation in 2009-2013[136]

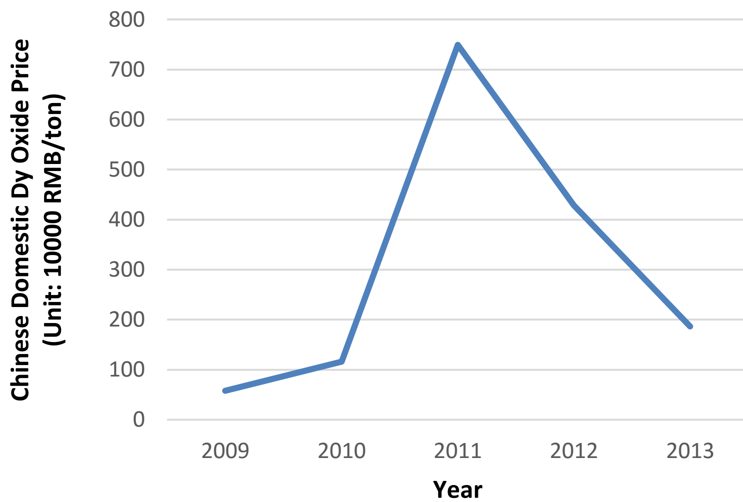

Figure 19 Chinese Domestic Dysprosium Oxide Price Fluctuation in 2009-2013[137]

[136] Data Source: InvestorIntel (http://investorintel.com/)
[137] Data Source: InvestorIntel (http://investorintel.com/)

For REE-enabled end products, the effect of REE price fluctuation can vary, and it may lead to adoption of suboptimal technology if REE-enabled technologies account for a significant fraction of total production cost. Take the wind turbine production vs. electric/hybrid vehicle production as an example. Costs for NdFeB permanent magnet account for about 20% of the production cost of the PM-enabled wind turbine. Because of the big price increase of the REE permanent magnet, wind turbine producers have been hit, and many chose to switch the magnets (at least in the short term) to cheaper alternatives. For producers of 1.5MW wind turbine direct drive PMG (priced at 8-10 million RMB), a four times price increase of permanent magnet materials (1.5 million RMB to 7.5 million RMB) in the first half of 2011 meant that if they could not raise the wind turbine price, they would have to choose substitutive magnets or else lose profit. On the other hand, the costs of NdFeB permanent magnets only account for about 1% of the total production cost of a typical EV or HEV. Thus there has not been significant change to the adoption of REE permanent magnet in automobile production despite of drastic price fluctuations of the REEs and permanent magnets.

4.7 China's Position in the Global Production Chain

This section analyzes China's position in the global production chain of REE-enabled technologies. The author finds that while China dominates global production in mining, processing, alloys, and increasingly permanent magnets, China lags behind the U.S. and Japan in high-value-added magnet production and end product manufacturing.

4.7.1 Dominating Mining, Smelting and Intermediate Production

China has a complete dominance in the production volume and technologies in the rare earth mining, smelting and further processing. Besides producing 90% of the global supply of REOs, China is also the only country that can provide commercial quantities of REOs of all grades and specifications. Specifically, China currently produces more than 97% of global output of Praseodymium and Neodymium Oxides, as well as more than 99% of global output of Dysprosium and Terbium. China produces about 90% of the global output of rare earth metal alloys.

4.7.2 Catching Up in Value-Added Magnet Production

China has also grown to be the largest producer of REE permanent magnets in quantity. In 2013, China's NdFeB permanent magnet output was 94 kilo-tons, accounting for 91.0% of the global output. (ResearchInChina, 2014) This is the result of both rapid expansion of permanent magnet industries within China and the closure of western production capacity. General Motors created the Magnequench Division in 1986 to produce NdFeB magnets. In 1995 GM divested itself of Magnequench, and a consortium of companies (including two Chinese state-controlled firms China National Non-ferrous Metals Export & Import Group and Zhongke San Huan) acquired Magnequench. In 2001 Magnequench closed U.S. production and consolidated all its production to China.

In terms of quality of production, however, China primarily produces relatively low-valued permanent magnets, compared to the other major producer Japan which produces and exports high-priced high-performance permanent magnet. In 2013, China's high-performance NdFeB PM output was merely 22 kilo-tons, sharing 54% of the global total. (ResearchInChina, 2014) Three Japanese corporations, Hitachi Metals[138], Shin-Etsu Chemical and TDK (including their foreign subsidiaries) on the other hand have 48% of the world's high-performance NdFeB PM market. (ResearchInChina, 2014) To satisfy the

[138] Hitachi Metals holds 615 patents as the world's largest manufacturer of high-performance NdFeB permanent magnets.

demand from China's downstream manufacturing industries, China still needs to import significant amount of these high-end REE permanent magnets from abroad (the imported REE permanent magnets are much higher valued per unit than exports, as shown in Figure 20 and Figure 21).

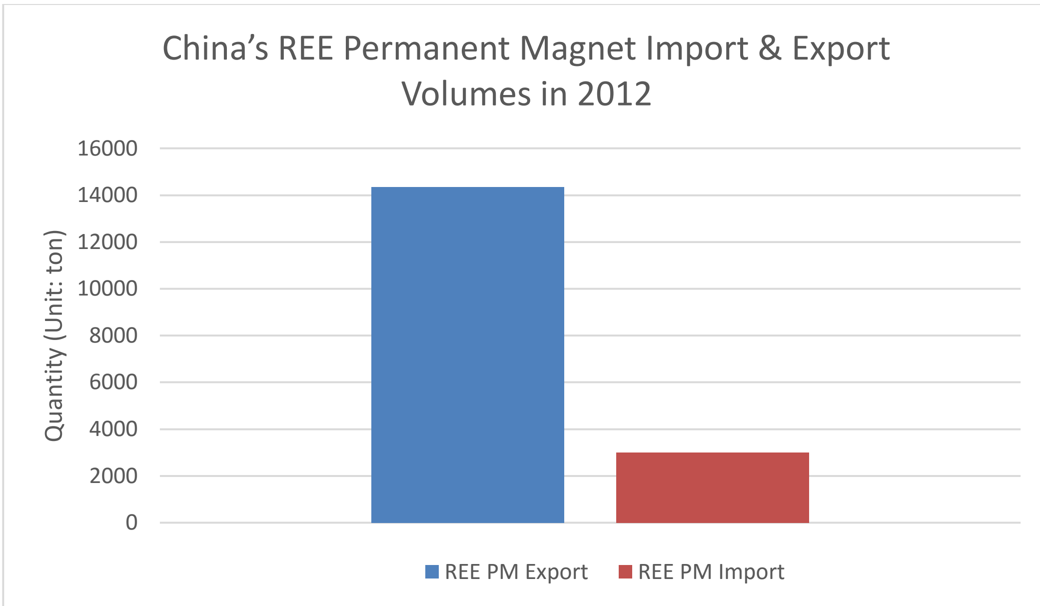

Figure 20 China's REE Permanent Magnet Import & Export Volume in 2012[139]

[139] Data Source: 2012 *Annual Review of the Rare Earth Industry*, published by MIIT (Ministry of Industry and Information Technology of China)

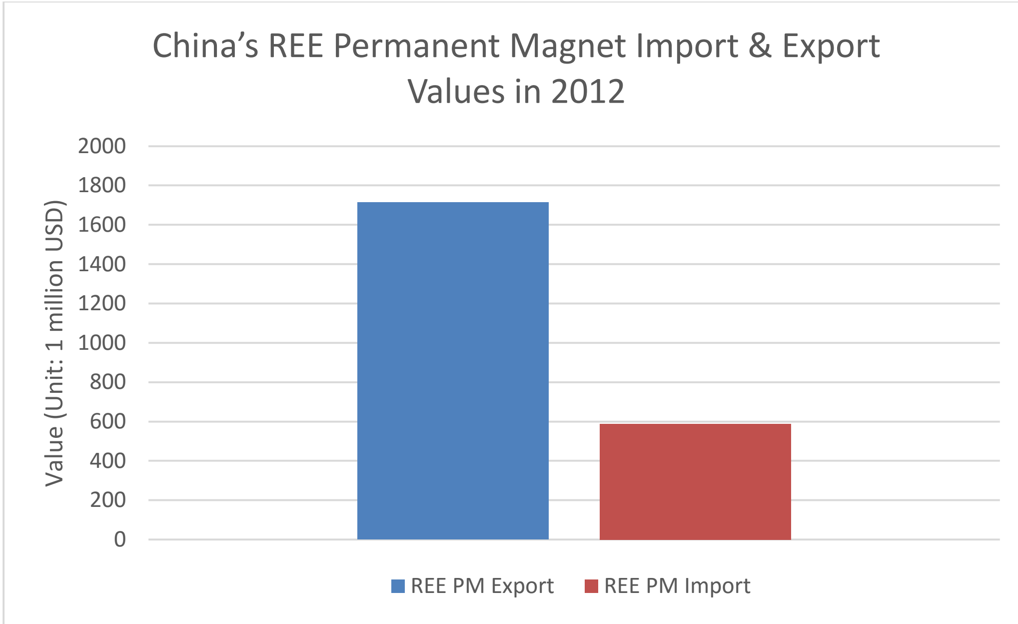

Figure 21 China's REE Permanent Magnet Import & Export Values in 2012[140]

4.7.3 Lagging Behind in End Product Manufacturing

China lags behind the OECD countries in both production and innovation of the downstream products. As Table 5 shows, while Chinese companies dominate the upstream production, companies in Japan, the U.S. and Europe are the major market players in high-performance permanent magnets and end products including wind turbines and EVs. Although China has been called the world’s “turbine making hub”, Chinese manufacturers of wind turbines in fact have minority share of global market revenues. Chinese producers account for about 25% of the global market share (Figure 24 shows the ten largest suppliers in the global wind turbine market). China is also still far away from becoming a major global player in electric vehicle (EV) production. The EV

[140] Data Source: 2012 *Annual Review of the Rare Earth Industry*, published by MIIT (Ministry of Industry and Information Technology of China)

market is a fairly small but growing market within the automobile sector, with more than 180,000 vehicles in stock representing 0.02% of total passenger cars. (IEA, 2013b) In EV and HEV production (except mild hybrids), permanent magnet motor production is integrated within the manufacturing process, therefore vehicle manufacturers produce their own drive motors and there is no outside individual vendor[141]. Currently major producers of EVs are Japanese and American firms (see Table 5), whereas China has not started producing them in large quantity.

On the other hand, rising energy consumption and serious environmental issue make China a strong market for alternative energy products. China has a rapidly growing wind energy market (see Figure 22) that has overtaken the U.S. to become the world's largest wind market in the past six years. (Bloomberg New Energy Finance, 2015) While the electricity generated by wind power accounted for just 2.6% of the national total in 2013 (GWEC, 2014), National Development and Reform Commission (NDRC) has set the target of 200GW installed wind energy capacity by 2020, which would account for 30% of China's electricity generation. (NDRC, 2014) Similarly, China is also a rapidly growing market for electric vehicles (see Figure 23). By mid-2013, China had only about 40,000 electric/hybrid vehicles on the road, of which roughly 80% were public fleet vehicles such as buses and sanitation vehicles. (Howell et al., 2014) In the "12th Five-Year Plan for Electric Vehicles Technology Development" released by the Ministry of Science and Technology, the Chinese central government has made the target of deploying 500,000 electric/hybrid vehicles by 2015. (MOST, 2012)

[141] For instance, Toyota (Japan), Mitsubishi (Japan), Nissan (Japan) all manufacturer motors within their own production lines.

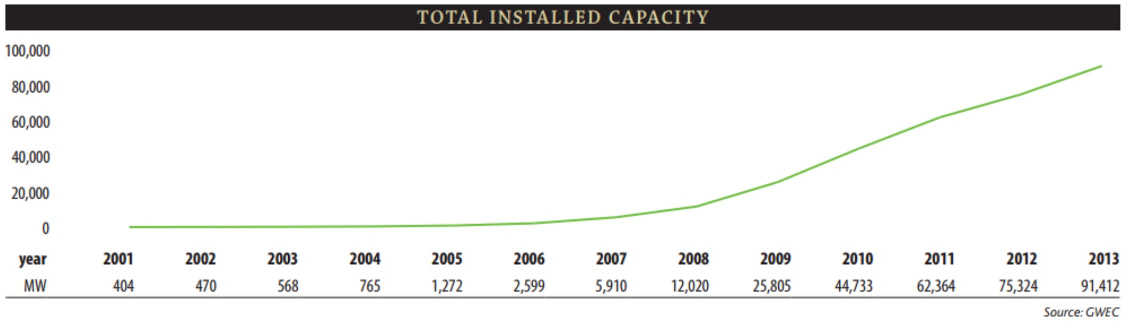

Figure 22 China's Wind Energy Installed Capacity in 2001-2013[142]

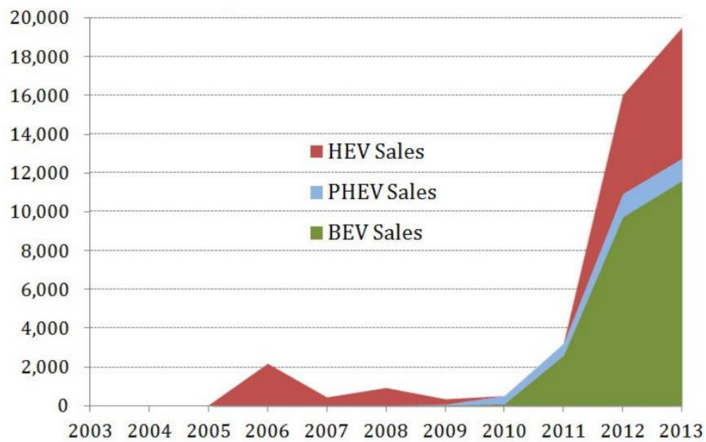

Figure 23 China's Electric Vehicle Market Growth in 2003-2013[143]

142 Source: (GWEC, 2014)
143 Source: (Howell et al., 2014)

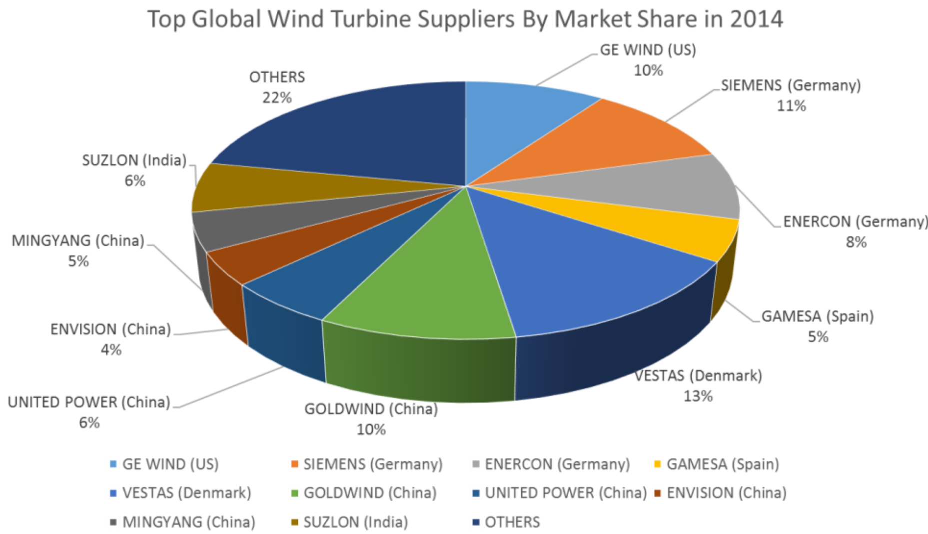

Figure 24 Global Wind Turbine Suppliers Market Share in 2014[144]

[144] Data Source: (Navigant Research, 2015)

Table 5 Major Companies in China, Japan, India, North America and Europe in REE-enabled Production Chain

	REE	Permanent Magnets (PM)	PM Generators & Wind Turbines[145]	PM Motors & EVs[146]
China	Baotou Steel; Ganzhou Rare Earths; Guangdong Rising; China Minmetals; Xiamen Tungsten; China Aluminium	Beijing Zhongke San Huan Hi-Tech; Ningbo Yunsheng Hi-Tech Magnetics; Sinosteel AT&M; Yinghe Magnetics; Zhenghai Magnetics;	Sinovel; Goldwind; Guodian United Power; Dongfang Electric;	BYD; Kandi; Chery; Zotye; Geely
Japan		Shin-Etsu Chemicals; Hitachi Metals; TDK; Sumitomo Metal Mining Co. (SMMC)		Toyota; Honda; Nissan; Mitsubishi

[145] The suppliers of permanent magnet (PM) generators used for wind turbines are highly integrated with the manufacturers of the wind turbines, so our analysis groups the analysis for their market share together.

[146] Permanent magnet motor production is integrated within the manufacturing process, therefore vehicle manufacturers produce their own drive motors and there is no outside individual vendor. Toyota (Japan), Mitsubishi (Japan), Nissan (Japan) all manufacturer motors within their own production lines.

Table 5 (Continued)

India			Suzlon	
North America		Arnold Magnetic Technologies; OM Group (supplies German automobile company)	General Electric	General Motors; Ford; Tesla
Europe		Vacuumschmelze; Neoren Magnets	Vestas; Gamesa; ENERCON; SIEMENS	Daimler; Renault; BMW

There is, therefore, a mutual dependence between China and the West (U.S., Europe and Japan) within the rare earth production chain (see Figure 25 for illustration). This means that China's reregulation has profound influence on downstream industries and markets across national borders. China enjoys some technical advantage and especially production and market predominance in upstream mining and smelting. Such dominance is unlikely to change in the near future. China has also become the major rare earths market in the world, due to its production and market predominance in the intermediate production (such as alloy making) and low-end components (permanent magnets) production. On the other hand, Japan, the U.S. and Europe have technical advantage and market dominance in producing high-value-added components (permanent magnets) and end products (for instance electric vehicles). China is becoming a significant market for these Western-produced high-value end products due to the country's transition to low-carbon economy. Such mutual dependence of technologies, production and markets makes it highly difficult for Western countries to build up a completely non-Chinese production chain even if non-Chinese junior miners can survive their financial challenges. While China's technological capability is evidently superior in upstream and midstream, it still lags behind the advanced economies in downstream production and aspires to import high-value downstream products. This also forms a technical rationale for the Chinese state to enhance its control over the industry, in order to preserve and capture more of the value of these non-renewable minerals.

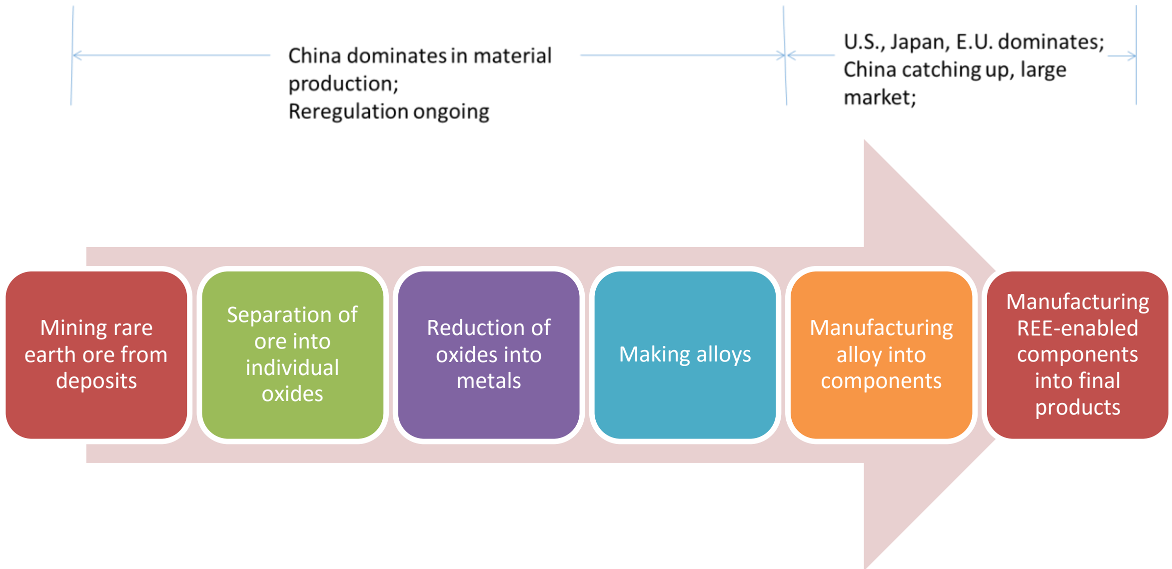

Figure 25 Mutual Dependence between China and the West across the Rare Earth Industry Production Chain

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CHAPTER 5 STATE-LED DEVELOPMENT UNDER PLANNED ECONOMY (1949-1977)

This chapter analyzes the development of the rare earth industry in China under the planned economy from the founding of the PRC in 1949 to the late 1970s. In this period preceding state reregulation of the industry in the economic reform and marketization era (1978-present), the state built up the foundational capacity for industry development, though the overriding emphasis was on its utility for national defense and heavy industries. The importance of REEs as critical minerals were well recognized by senior Chinese government officials. Due to western embargo and later Sino-Soviet split, importing advanced technologies and industrial products was difficult for the young regime. Developing the world's largest REE deposits and producing applications including materials for advanced weapons, steel products, lighting and displays[147] were appealing to the state. As the most important actor in the planned economy, the state championed industry development through prioritizing resources allocation, establishing research institutions and state-owned companies, and setting targets for industry output and technology breakthroughs. Such institutional support allowed the industry to bypass fiscal and technical constraints typical in junior mining project development within a short period of time. In this planned economy era, the state's overshadowing both the economic and the science and technology (S&T) institutions proved to be not just a blessing, but also a curse. Successive political campaigns including the Cultural

[147] REE permanent magnets were not invented until 1982, thus the major applications then differed greatly from the major applications of REE today.

Revolution led to delays in science and technology development and hampered overall economic development. Fortunately, the rare earth industry as part of the military-industry complex received comparably better protection from the state planning. By the end of the Cultural Revolution era, emerging good relations with the Western countries and more stable domestic political environment resulted in new state institutions and faster progress in rare earth industry development.

5.1 Pre-PRC Rare Earth Deposit Discovery

The earliest discovery of geological deposits containing rare earths in China was the discovery of Baiyun-Ebo iron deposit by a Chinese geologist Ding Daoheng on a joint exploration led by Peking University professor Xu Xusheng and Swedish geographer Sven Anders Hedin in 1927. (Du, 1993) Rare earth elements were confirmed from analysis of the deposit by acclaimed Chinese geologist Ho Tsolin in 1935. (Zhang et al, 1985) From the 1920s until 1949 China was plagued by civil wars between military forces loyal to the Nationalist Party (then ruling party of the Republic of China) and forces loyal to Communist Party of China (now ruling party of the People's Republic of China). The country also suffered severe devastation because of the Japanese invasion in the Second Sino-Japanese War (1937-1945). There was ongoing scholarly research on geological deposits in the region, but no active mining projects existed before the Communist Party takeover and founding of the People's Republic of China in 1949. (Chinese Academy of Sciences, 2009)

5.2 Developing the Rare Earth Industry for National Defense

After the founding of the PRC in 1949, the Chinese state nationalized all lands and natural resources and all industries[148] in the 1950s. A centralized, top-down planning system for research and industry development was established following the Soviet model. With regard to mineral resources, the central government became the sole owner of resources and had total control over production and product allocation. Companies were all state-owned, functioning as extensions of government bureaus; company managers were appointed by the government as well. Mining activities were conducted according to central government's planning, with no resource tax levied on extraction or for environmental protection. [149] Thus state priority and allocation of resources were crucial for industry development.

The central government restarted geological exploration of the Baiyun-ebo region. A preliminary mining project to extract iron, the primary mineral of the deposit for steel production was officially started in 1953. [150] The Ministry of Heavy Industries[151] (重工业部) reported to the State Planning Commission[152] (SPC, 国家计划委员会) that the Baiyun-ebo deposits in Inner Mongolia, a major iron ore deposit, also contained various

[148] Private firms, which were common in the Republic of China era, were eliminated and replaced by so called "joint-ownership firms" (公私合营企业) which were in fact wholly-state-operated entities. The former factory owners became state employees, and could not exercise real managerial duties. (Perry, 1994)
[149] For an overview of the evolvement of property rights concerning China's mineral resources, see Jiang (2012). Jiang Xinmin is the Vice Director of the Energy Economics and Development Strategy Research Institute within the Energy Research Institute of the National Development and Reform Commission (NDRC).
[150] See the iron mine website at http://www.byebtk.com/bytk/Main.asp
[151] Ministry of Heavy Industries was abolished in 1956 to form three new separate ministries, Ministry of Metallurgical Industry, Ministry of Chemical Industry and Ministry of Building Materials Industry. (Xinhua, 2013)
[152] The State Planning Commission was the leading macroeconomic management agency which oversaw China's centrally planned economy. In 1998 it was changed into National Development Planning Commission, and in 2003 it was merged into the newly formed National Development and Reform Commission. (Xinhua, 2013)

kinds of rare earth elements, and "how to extract and refine this specific resource is a significant issue." (PRC Ministry of Heavy Industries, 1953) At this time, China received technical assistance for developing industries from the Soviet Union through the *Agreement on Joint Development and the U.S.S.R. assistance to China in Prominent Science and Technology Research* (<<关于共同进行和苏联帮助中国进行重大科学技术的协定>>) signed in 1958. With technical assistance from scientists from the Academy of Sciences of the USSR, the Chinese Academy of Sciences (CAS) conducted exploration of the Baiyun-Ebo deposit region, concluding that the estimated reserves volume would make Baiyun-ebo the world's largest known REE deposit. Yet with the gradually worsening of the Sino-Soviet relations, Soviet Union withdrew its assistance in July 1960 and all experts previously dispatched by the Academy of Sciences of the USSR to China were summoned to leave China. (Zhang, 2012) The withdrawal of Soviet support, coupled with existing security threats and economic sanctions by the Western bloc prompted Chinese leaders to advocate for "self-reliance" (自力更生) of military technologies and industrial production.[153] The development of industrial materials and indigenous technologies for national defense became priority on the state development agenda.

A central political figure in elevating the importance of the rare earth industry was Vice-President of the Central Military Commission, Marshall Nie Rongzhen. As one of the ten supreme marshalls of the People's Liberation Army (PLA), Nie oversaw China's defense and civilian technology development as the chair of both the State Science and Technology Commission (SSTC, 国家科委) and the National Defense Science and

[153] See the *1956-1967 Science and Technology Development Long-term Plan* at http://www.most.gov.cn/ztzl/gjzcqgy/zcqgylshg/200508/t20050831_24440.htm.

Technology Commission (NDSTC, 国防科委) [154]. In 1960 Nie spoke on the importance of REEs to China's national defense and military autonomy, saying that "many countries rely on their domestic resources to produce alloyed steel for industries and defense, and we have not achieved that…now the use of rare earth alloys in steel is a historical progress. China has large rare earth deposits that can be utilized, and we could do whatever we can to promote their use comprehensively." (Nie, 1999) In a report to the Central Committee of the Communist Party of China about the Baiyun-ebo region, Nie wrote that "such abundant deposits of REEs and rare metals are rare even around the world", and "such large deposits with strategic significance at the heart of China's inland must be studied with all efforts, and used comprehensively." (Nie, 1960) Deng Xiaoping, then Vice President of the State Council issued similar remarks about the importance of developing the Baiyun-ebo deposit in 1964 after visiting Baotou, "Baiyun-ebo mine is a precious resource that we need to make good use of. We need to produce both steels and REEs and make comprehensive use of the precious mineral resources." (Sun, 2001)

In accordance with then common practice of establishing state-owned military-industrial programs for developing science and technology, the state established research institutes and military-affiliated factories across China to develop REE mining and smelting capability in the early 1960s. In 1962 the SPC, the SSTC, the NDSTC and the

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[154] The SSTC and the NDSTC were established in 1958 to consolidate civilian and military science and technology research institutions, after the PRC central government released its first long-term plan to develop its science and technology in 1956, *1956-1967 Science and Technology Development Long-term Plan [1956 年至 1967 年科学技术发展远景规划]*. The SSTC was renamed the current Ministry of Science and Technology in 1998. The NDSTC was merged into the Commission for Science, Technology and Industry for National Defense (COSTIND) in 1982, and most of its defense procurement functions were merged into the State Administration for Science, Technology and Industry for National Defence (SASTIND) under the current Ministry of Industry and Information Technology (MIIT) in 2008. (CAS, 2009a)

Ministry of Metallurgical Industry jointly formed "Baotou Steel Rare Earth Temporary Working Group" (包头稀土临时协调小组), an inter-ministry group in the State Council to oversee national research and development on the Baiyun-Ebo deposit. (Ma, 2012) In 1963 Marshall Nie Rongzhen directed the Ministry of Metallurgical Industry [155] to establish Baotou Metallurgical Research Institute（冶金工业部包头冶金研究所） and assign more than 300 scientists from around the country to work on REE extraction and processing[156]. (Ma, 2012) In 1963 and 1965 Nie Rongzhen directed the SSTC, CAS and the Ministry of Metallurgical Industry to host two national conferences about Baotou's deposit and its rare earth applications (包头矿综合利用和稀土应用工作会议)[157]. In mid-1960s Baotou Steel Factory, the state-owned factory producing steel from the Baiyun-ebo deposit under the control of the Ministry of Metallurgical Industry, started producing rare earth ore concentrates with the grade of about 30% REO (rare earth oxides). (Zhang et al, 1982) General Research Institute for Nonferrous Metals (GRINM, 有色金属研究总院)[158] a central-government-controlled research institute responsible for

[155] Ministry of Metallurgical Industry oversaw all major metal companies, research institutes and local bureaus of metallurgical industry. It was abolished in the 1998 State Council bureaucratic reform. (Xinhua, 2013)

[156] Baotou Metallurgical Research Institute is the predecessor of Baotou Research Institute of Rare Earths (BRIRE, 包头稀土研究院), now the largest research institute devoted to REE research in the world. For more information, see the institute website at www.brire.com.

[157] These two conferences, later referred to as "415 conferences" by popular media as they were held on April 15th, were instrumental in finalizing China's approach to developing the Baiyun-ebo deposit. Based on conference discussions, the leadership made the decision to develop both iron mining and processing technologies, as well as REE mining and processing. (Zhang, 1965)

[158] GRINM is now under the direct supervision of State-owned Assets Supervision and Administration Commission. It hosts National Rare Earth Materials Engineering Research Center, and is the major shareholder of Grirem Advanced Materials, a major

developing technologies in non-ferrous metals and materials in Beijing, began to produce individual oxides in 1962. Shanghai Yaolong Chemical Plant[159] (上海跃龙化工厂), one of the earliest rare earth smelting and application company in China, started processing monazites containing REEs in 1964. Several other smelting and processing plants were established in South China, including Guangdong 661 Factory[160] in Guangdong Province and Jiangxi 801 Factory[161] in Jiangxi Province.

5.3 Political Campaigns Hampered Development

The state's control over the industry and the science community was a double-edge sword: state planning of economic output, combined with nationalization of resources and mining rights guaranteed the resources and demand to develop research capacity and production capacity within a short period of time, bypassing the fiscal and technical constraints commonly found in junior mining projects in market economies. On the other hand, state campaigns driven primarily by political ideologies seriously

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Chinese advanced rare earth materials producer which has a production capacity of about 10000 ton/year. For more information, see the GRINM website at http://www.grinm.com.

[159] Shanghai Yaolong Chemical Plant is the predecessor of Shanghai Yuelong Rare Earths New Materials Company, now one of the largest rare earth processing and fabrication companies in China. It now specializes in producing rare earth phosphors for lighting, individual REOs, and LED powders. For more information, see the company website at http://www.newyuelong.com.

[160] Guangdong 661 Factory is the predecessor of Guangzhou Zhujiang Rare Earth Company, currently a major rare earth oxide producer in China. Chinese central-government-controlled firm China Non-ferrous Metal Mining Group now owns majority share of the company. For more information, see the company website at http://www.gdzjre.com/

[161] Jiangxi 801 Factory is the predecessor of Nanchang Cemented Carbide Ltd., now the largest producer of tungsten oxide in China. Chinese central-government-controlled firm China Minmetals now owns majority share of the company. In 1984 Jiangxi 801 Factory's rare earth production line and workforce were separated from the factory to become part of the newly created Jiangxi Rare Earths Company, the predecessor of the current Jiangxi Rare Earth And Rare Metals Tungsten Group Corporation (major natural resource firm controlled by Jiangxi Province government). For more information, see the company website at http://www.jxtc.com.cn/

hindered the science community’s freedom of inquiry and severely hampered the state’s development efforts.

The state’s ambivalent treatment towards highly-educated intellectuals stemmed from conflicting ideologies regarding the position of intellectuals in the new socialist state. On the one hand, communist leaders recognized that intellectuals were indispensable to the development of the socialist economy and national defense for China. On the other hand, Chairman Mao Zedong emphasized “class struggle between the proletariat and the capitalists” as the primary political issue for the Chinese Communist Party in post-revolutionary China. (Mao, 1957) Highly-educated intellectuals should be subject to close scrutiny and should not be trusted as true communists. (Mao, 1925) Thus freedom of intellectual pursuit and criticism could be sacrificed for political correctness. A case to illustrate this concerns the “Great Leap Forward” campaign: Mao proclaimed that “China would overtake Britain in production of steel and other products within 15 years”, and people who did not agree with the proposed radical plan of steel production were persecuted. (Yang, 1996)

Thus not surprisingly, the state in the Mao era had conflicting and often reversed policies towards researchers and research projects based on the political campaigns of that time, leading to many setbacks in development. During the Sino-Soviet cooperation era in the early 1950s, researchers who criticized Soviet-style education and Soviet expert opinions were punished. In the case of the REE mining, Soviet experts proposed mining the Baiyun-Ebo deposit primarily for iron and steel production instead of developing technologies for both iron and rare earth production. Some Chinese scientists opposing the Soviet recommendation were regarded as “anti-Soviets” and were required to write self-criticism testifying their allegiance to the Communist leadership. (Yap, 2011) The Hundred-Flowers Campaign (百花运动) in 1956 was a brief state campaign to encourage highly-educated intellectuals to be more vocal in opinions and criticisms about party policies. Yet the immediate Anti-Rightist Campaign (反右运动) of late 1957-1958 saw the prosecution of intellectuals across the country alleged to be "rightists who harbor anti-communist thoughts". [162] Fortunately, then CAS Party Secretary Zhang Jingfu successfully persuaded Mao to exclude scientists working at the Chinese Academy of Sciences from the Anti-Rightist Campaign, including scientists at the Institute of Process Engineering who worked on mining and smelting technologies. (Yang, 2009)

After the Anti-Rightist Campaign and the Great Leap Forward of 1958-1960, the state sought to restore its damaged relations with the science and engineering community. Premier Zhou Enlai and Vice Premier Chen Yi recognized scientists as "people's scientists, socialist scientists and proletariat scientists" at the "Guangzhou Conference" in 1962 to remove the intellectuals' political sin as "capitalists". (Liao, 2002) Such recognition inspired great enthusiasm from the science community to participate in national research agendas. Yet progress was short-lived.

The Cultural Revolution (1966-1976) had "long and devastating" effect on "China's scientific enterprise and scientists". (Cao, 2013) Political struggles within the Party leadership resulted in the dominance of radicals, and the purge of senior leaders including Nie Rongzhen and other key leaders of the SSTC and the CAS from positions of power. (Cao, 2013) Highly educated intellectuals were regarded as the "stinking ninth

[162] For a detailed account of the persecution of intellectuals during the Anti-Rightist Movement, see Shapiro (2001).

category"[163], the lowest of the low to be persecuted. Millions of scholars, managers, technicians, and government officials were purged from their positions, executed based on unfounded charges, suffered public torture, or sent to labor camps. (Macfarquar & Schoenals, 2006) A prominent example for the rare earth industry is Chu-Phay Yap, director of Chemical Engineering and Metallurgical Research Institute at CAS. Prof. Yap, a prominent scientist and returnee from the U.S., was first labeled as "anti-Soviet" for proposing to develop REE mining for the Baiyun-Ebo deposit in the 1950s. Yap was then detained in 1966 for unfounded spying charges and died in 1971. (Yap, 2011) The Cultural Revolution left most of China's science and education institutions paralyzed. It also damaged the national economy, and by early 1970s the economy worsened to the brink of collapse[164].

5.4 Industry Growth despite Political Turbulences

While the Cultural Revolution seriously hampered China's science institutions and economic development, the rare earth industry still had some progress in the development of separation and purification technologies and new geological exploration. Overall military technology research programs enjoyed some protection from radical political campaigns in the Cultural Revolution due to their importance to national security. (Brock, 2009) Because of the close ties with national defense, rare earth projects were

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[163] Campaigns in the Culture Revolution aimed to purge "Five Black Categories" (landlords, rich peasants, counter-revolutionaries, bad elements, and rightists), traitors, foreign agents, "capitalist-roaders" (cadres) and "reactionary academics" (teachers and other intellectuals). Thus academics were regarded as the "stinking ninth category."

[164] For an official account of the damage of the Cultural Revolution, see then President of the Central Committee of the Communist Party of China Hua Kuo-feng's report to the 5th National Congress in 1978. (Hua, 1978) According to Hua, between 1974 and 1976 the Cultural Revolution had caused losses worth 100 billion Yuan in state revenue, and "The national economy was on the brink of collapse."

also given relatively better priority and protection than purely civilian research. Take the "Separation of Nd-Pr Concentrates" project as an example. Neodymium (Nd) was the most common material used in solid-state lasers for military purposes; yet by 1971, China was only able to produce rare earth concentrates that contained several coexisting REEs [165], which then had to be sold to the French company Rhone Poulenc for separation[166]. The Bureau of Metallurgy within the People's Liberation Army (PLA) made it a priority to develop indigenous technology to separate the coexisting REEs and produce highly enriched Neodymium, which could then be used to produce laser weapons. Researchers were grouped together in Beijing to work on the project. Among them was Mr. Xu Guangxian[167], a chemist who was called back to Peking University from detention in a labor camp in Jiangxi Province. (Jia & Di, 2009) Mr. Xu, now regarded as "Father of China's Rare Earth Industry", developed the "Countercurrent Extraction Theory" （串级萃取理论）, the theoretical foundation for extraction technologies separating and producing highly purified, individual rare earth oxides from ores in China. (Xu et al, 1985) In 1975, highly enriched rare earth concentrate (REO > 60%, compared to just 30% in mid-1960s) was successfully produced from bastnasite deposit in Prof. Huang Guoping's lab in Guangzhou Non-ferrous Metals Research

[165] Take the Baiyun-Ebo bastnasite deposit as an example. The deposit contains the oxide form of several REEs, including Ce (roughly 50%), La (roughly 25%), and Nd-Pr Concentrates (roughly 25%) containing more than 10 chemical elements. Existing technology by 1971 could only separate Ce and La from the Baiyun-Ebo ores.

[166] Rhone Poulenc is the predecessor of French producer Rhodia, now acquired by Solvay. Rhone Poulenc was the only European producer of all purified rare earth oxides before the 1970s. In 1964 France and the People's Republic of China established ambassadorial level diplomatic relations. China still faced embargo from the U.S. and most of its allies, thus Rhone Poulenc was the primary producer processing China's rare earth concentrates.

[167] In English-language scientific publications Prof. Xu also published under the name of Hsu Kwang Hsien.

Institute. (Huang et al, 2006) Some other important technological breakthroughs during the Cultural Revolution included producing purified yttrium oxide in 1970, producing purified lutetium oxide in 1971, producing rare earth chloride in 1972, producing purified scandium oxide in 1972, and producing Samarium Cobalt permanent magnets in 1974. (Office of Shanghai Chronicles, 1999) In the Gannan-Yuebei region in South China, ion-adsorption clay deposit was discovered in 1968, and Jiangxi Non-ferrous Metallurgical Research Institute conducted research in 1970-1975 regarding the deposit's geological formation, extraction and separation methods. (Huang et al, 2006) The deposit would prove to be China's largest source of the HREEs after the Cultural Revolution.

More favorable international and domestic political environment at the end of the Cultural Revolution era led to new state initiatives in rare earth industry development. Internationally, China began to restore diplomatic relations with the U.S.[168] and Japan[169] in 1972, leading to substantial trade opportunities of exporting raw materials to the international market of the U.S. and its allies. In 1974, Ministry of Metallurgical Industry directed Baotou Steel, the parent company in charge of the Baiyun-Ebo deposit, to set up capacity to produce sizable amount of rare earth oxides for export. (Shen & Zhao, 2012) Domestically, the brief resurgence of pro-economic-development leader Deng

[168] After U.S. President Nixon's visit to China and the release of the Shanghai Communiqué in 1972, U.S. and People's Republic of China began to restore diplomatic relations and trade relations, although ambassador-level diplomatic relations did not fully resume until 1979 under the Carter Administration. For a timeline of important events in U.S.-China relations, see http://www.cfr.org/china/us-relations-china-1949---present/.

[169] Japanese Prime Minister Kakuei Tanaka visited China in 1972, and the two countries established diplomatic relations on September 29, 1972. (Ministry for Foreign Affairs of Japan & Ministry for Foreign Affairs of the People's Republic of China, 1972)

Xiaoping[170] in the central power struggle in 1974-1975 led to a temporary state emphasis on economic development over ideological campaigns.

Specifically the establishment of an inter-ministry working group within the central government at the end of the Cultural Revolution era would have significant impact in industry development in the decades to follow. In 1975 an inter-ministry working group called "National Rare Earth Applications Promotion Leadership Group" (全国稀土推广应用领导小组) was established in Beijing, composed of senior officials from the State Planning Commission, the Ministry of Metallurgical Industry and the Chinese Academy of Sciences. Despite of several name changes, the group remained to be the direct national administrative body overseeing the industry development until the early 2000s. (Su, 2009, p. 269) From 1975 to 1977, the group led initiatives promoting industrial applications and science outreach, including hosting the "National Rare Earth Applications Exhibition" (全国稀土推广应用展览会) which held nation-wide exhibition tours and 283 public lectures and seminars around the country. Such public outreach and

[170] As an influential army leader, Deng Xiaoping championed China's economic reconstruction in the early 1960s with other pro-development leaders after the economic failure of the Great Leap Forward (1958-1961) instigated by Mao. Deng was purged from the central leadership at the start of the Cultural Revolution on "capitalist" charges. From 1974 to 1975, Deng briefly returned to the party central leadership in charge of economic affairs, as a successor appointed by then Premier Zhou Enlai. Deng worked to restore major economic and governing institutions. However, Deng was purged again by Mao and his close associates the "Gang of Four" in February 1976, until Mao's death and the end of the Cultural Revolution. Deng emerged as the de facto leader of the party after Mao and launched China's market-oriented economic reform in 1978. For more information, see Deng's daughter's memoir *My Father Deng Xiaoping: Cultural Revolution Years* (Deng, 2000)

education initiatives gave the rare earth industry nation-wide visibility, which laid the foundation for widespread industrial production and market expansion in the 1980s. [171]

[171] See Dou (2012). Dou Xuehong is a retired rare earth expert and the former director of the Rare Earth Information Center at Baotou Research Institute of Rare Earths.

CHAPTER 6 STATE-LED RAPID MARKETIZATION AND DEVELOPMENT (1978-1997)

This chapter studies the rapid development of the rare earth industry and the state's role in its ascendance to global production dominance in just two decades in the post-Mao economic reform era. As the analysis demonstrates, industry liberalization and marketization is part of the state overall reregulation over the industry development. This chapter first analyzes the macroeconomic environment for the industry development. Under the leadership of pro-market "Second-Generation Leaders", particularly the core leader Deng Xiaoping, China started a state-led transition from the planned to the market economy. The chapter then analyzes the state goals and narratives in guiding the rare earth industry development in the reform era. Developing the rare earth industry served both strong economic interests of export growth and strategic interests strengthening ties with major global powers. The development narratives of the central government featured both marketization (promoting the development of international markets, industrial production and private sector) as well as regulation (keeping the industry boom under regulatory control). The chapter then examines specific state policies on industry development. Consistent with the dual narratives of liberalization and control, the central government championed the rapid development of the market economy, but never retreated from the market: it utilized existing planning institutions and introduced new rules and institutions to control rare earth mining, export and industry development. The chapter then analyzes changes in political institutions which resulted in the rapid expansion of the industry within China and the rise of local governments as strong political agents of development. The chapter concludes with analysis of the industry development results as outcomes of state reregulation. This chapter shows that the industry's rapid marketization and growth was achieved not despite of, but because of the Chinese state's direct involvement in market expansion, industry development and institution building for its own interests.

6.1 Macro-level Economic Change: Transition towards the Market Economy

The economic reform, known as "Reform and Opening" campaign, started in 1978 and transformed China from a planned economy to a market-oriented economy with high-speed export-led growth. This section summarizes major changes in China's macroeconomic reform from 1978 to 1997.

6.1.1 Incremental Reform to Build Market Economy

The macroeconomic environment after the Cultural Revolution for China was a shortage economy in desperate need of basic supplies and industrial production. Prior to 1978, production prices and quantity targets were set by the government, leaving little incentive for state-owned producers to produce more than the planned quota. Deng and the other reform leaders began to implement pro-market policies aimed to increase industrial output and export. The state introduced incremental reform measures to build a market economy alongside the existing planned economy.

The central government established a "dual-track system" in the early 1980s allowing companies to sell their surplus output at higher prices on the open market while still selling their planned quota production to the state plan at state-set prices. (China Internet Information Center, 2009b) Such a system incorporating both the "market" and the "plan" was applied not only to the price of raw materials and outputs, but also to other areas of economy including interest rates, exchange rates and labor. (Lin et al, 2003) Under the dual-track system, the market outside the planned system rapidly expanded, resulting in the rise of the private sector and the gradual transition from state-determined supply and demand to market-determined supply and demand. The state legally acknowledged its role in 1988 through constitutional amendment declaring that "the government protects the lawful rights and interests of the private sector of the economy, and exercises guidance, supervision and control over the private sector of the economy", and "the right to the use of land may be transferred according to the law." (China Internet Information Center, 2009a) By 1996, 81% of total sales volume of production was priced by the market, instead of the state plan. (Lin et al, 2003)

6.1.2 Reforming Science and Technology (S&T) Institutions for Economic Development

The state sought to repair its relationship with the science community damaged by the Cultural Revolution. At the National Science Congress in 1978, Deng made the famous remark that "intellectuals are part of the working class" (Deng, 1978), recognizing scientists and engineers as part of the new economic system under reform. The state re-established the SSTC in 1977, signifying a reversal of Cultural Revolution anti-intellectual policies. The state re-introduced National Higher Education Entrance Examination in 1977 and set up a system cultivating future S&T leaders, including projects such as the Hundred Talents Program (中科院百人计划)[172] and the Million

[172] The CAS implemented the Hundred Talents Program in 1994 which funded over 100 young scientists. The Hundred Talents Program of CAS was the first science talent recruiting and training program in China with "high aims, high standards and high level of support", and has been the backbone program for attracting and training academic and technological leaders. See http://www.cas.ac.cn/ggzy/rcpy/brjh/ for call for applications.

Talent Project (百千万人才工程)[173] funding young talents from both home and abroad and promoting them to key positions.

The state prioritized science and technology (S&T) research and development that could contribute to economic growth. According to Deng, China's development goals are "the modernization of agriculture, industry, national defense, and science and technology" (known as "four modernizations"), and among them "science and technology modernization is the key to four modernizations." (Deng, 1978) *Law of the PRC on Progress of Science and Technology* (introduced in 1993) legislated that the state would be "basing economic construction and social development on science and technology and orienting science and technology undertakings to economic construction and social development." The post-Cultural-Revolution SSTC (the predecessor of the current Ministry of Science and Technology) gradually became the leading state agency formulating national S&T development plans and policies, taking on the role of technology development and investment that had previously belonged to the NDSTC[174]. (Feigenbaum, 2003) Military technology R&D shifted from state plans to contracts, opening doors to civilian research institutes and firms. Military-affiliated research

[173] The Ministry of Personnel started implementing the Millions Talent Project with the mission of developing world-class science and technology experts and young talents in 1994, which was later joined by six other ministries. The Million Talents Project selected young talents in "disciplines with great importance to national economy and social development in natural science and social sciences" from home and abroad, and provided funding support, research program support, and professional development opportunities such as international exchange. For more information, see the implementation plan at the Ministry of Human Resources and Social Security website at http://www.mohrss.gov.cn/zyjsrygls/ZYJSRYGLSzhengcewenjian/201301/t20130115_82418.htm.

[174] NDSTC evolved into the Commission for Science, Technology and Industry for National Defense (COSTIND) in 1982, and COSTIND was merged into the MIIT as the State Administration for Science, Technology and Industry for National Defense (SASTIND) in 2008. (CAS, 2009a)

institutes and firms also went through the process of “transition of military technology for civilian use” (军工技术向民用转移) which channeled existing R&D capabilities towards development of high-tech civilian products and collaboration with civilian institutes. (PRC COSTIND, 1988; PRC COSTIND, 1997)

In accordance with the macroeconomic transition from the plan to the market, the state reformed the S&T development system from central planning to market-oriented institutions. (Central Committee of the Communist Party of China, 1985) Starting with the release of the *Central Committee of the Communist Party of China Decision on Science and Technology Development Reform* in 1985, the state implemented reform policies resulting in several major institutional changes. Firstly, the funding mechanism of S&T research shifted from central state planned funding to a combination of central government, local government and private funding through competitive funding contracts; the Natural Science Foundation of China (NSFC) was founded in 1986 to award and manage competitive state research grants. (PRC State Council, 1988) Secondly, there was a gradual shift of R&D responsibility from state bureaucracy to enterprises (both state-owned and private), as well as spin-off firms of state research institutes. The state encouraged scientists and engineers to commercialize their research through entrepreneurship, contracting technologies, or providing technical assistance for local-government-controlled or private firms. (PRC State Council, 1996) Finally, the state began to set up “National High-tech Industrial Development Zones” (国家高新技术产业开发区) in select cities in order to boost foreign investment in high-tech production, technology transfer and commercialization. From 1988 to 2001 54 National High-tech Industrial Development Zones were established. (PRC MOST, 2011)

6.1.3 Dismantling State Planning in Rural Areas

From 1979 to 1983, the "household responsibility system" was adopted across China, dismantling the collective farming under the planned economic system. (China Internet Information Center, 2009c) While the state remains the legal owner of land, the household responsibility system allows rural households to contract land from the state and keep surplus production above quotas to be sold on the market. (Lin, 1988) The adoption of the household responsibility system, combined with the relaxation of control over labor migration from farming to township enterprises and urban factories, provided labor for the development of rural cooperative companies and urban industries. (Yang & Zhou, 2007)

6.1.4 Reforming State-owned Enterprises (SOEs)

Along with developing the private sector, the state gradually downsized the state-owned economy and recalibrated its control mechanism from direct planning of production and distribution to more indirect intervention through industry-specific regulations, quasi-government industry associations[175], personnel appointments[176] and

[175] An example in the mining industry is the China Iron and Steel Association, which was established in 1998 after the abolishment of the Ministry of Metallurgical Industry. The Association shares the same physical address with the former ministry. As a national level industry association, China Iron and Steel Association (CISA) have continued to exercise some functions of the abolished ministry. For instance, CISA represented Chinese steelmakers in talks with global miners on iron ore prices. The Chinese Society of Rare Earths (CSRE), the national level academic society specifically for the rare earth industry, has been receiving direct instructions and personnel management from the CISA. For more information, see the association website http://121.42.137.177/rareearth/learnintroduce/introduction/ for more information.

[176] Based on author's observation in China, the Department of Organization of the Communist Party of China determines party personnel appointments, promotions and dismissals in SOEs. Party committees and party secretaries in SOEs often also double as firm chairman or CEOs. Thus the party still in effect controls personnel appointment of the leadership of the SOEs.

loans from state-owned banks[177]. At the 3rd Plenary Session of the 12th Central Committee of the Communist Party of China in 1984, central leaders announced the SOE reform to "allow the enterprises to become relatively independent economic entities, socialist producers which have independence in operation and profit-loss." (Zhou & Xia, 2008) From 1978 to 1992, the share of industrial output by state-owned enterprises (SOEs) fell from 78% to 48%, no longer claiming the majority share of the national output. (Naughton, 1994) In 1995 the 14th Central Committee of the Communist Party of China identified the strategy of "grasping the large and letting go of the small." (Central Committee of the Communist Party of China, 1995) The state began to give up its control of small-sized SOEs through selling, leasing, downsizing, contracting out, merging with other firms, or allowing them to go bankrupt. Large and middle-sized SOEs started lengthy reform processes from wholly-state-owned firms to shareholding firms in which the state controlled complete or majority share. (Central Committee of the Communist Party of China, 1999)

6.1.5 Promoting Export-led Growth and Foreign Direct Investment

The macroeconomic reform also featured policies incentivizing export-led growth and foreign direct investment. Starting in the early 1980s the state created dozens of "special economic zones" (SEZ) that enjoyed preferential trade and investment environment in China's coastal provinces. The SEZs enjoyed reduced or eliminated tariffs, favorable policies regarding foreign direct investment (FDI) and technology transfer, as well as flexible economic measures to promote export-oriented manufacturing. (China Internet Information Center, 2009d) The state introduced export tax rebate

[177] Wei & Wang (1997) found that Chinese state-owned banks lending is biased in favor of the SOEs.

policy[178] in 1985 providing rebate money to exporting enterprises for the indirect tax they pay in the production and distribution process. (PRC Ministry of Finance, 1985) From 1991 to 1997 export tax rebate consumed about 20%-38% of the central government's annual total expenditure. (Cui, 2003) Such favorable trade policies, combined with strong growth in foreign investment and domestic manufacturing, resulted in Chinese exports rising on average 5.7% in the 1980s and 12.4% in the 1990s. (IMF, 2006) In financial markets, the state allowed limited trade of stocks and bonds in the late 1980s and formally established the Shanghai Stock Exchange and the Shenzhen Stock Exchange in 1990 and 1991, although foreign investment in stocks has still been controlled through currency control. (China Internet Information Center, 2009e) The state incrementally reformed its foreign exchange system and made the Chinese currency RMB convertible on the current account in 1996. (China Internet Information Center, 2009f)

6.2 Goals and Narratives of the State

This section studies the state's goals and narratives in developing the rare earth industry, narrowing the focus from China's larger macroeconomic transition to the rare earth industry itself. In this period in the post-Mao economic reform era, the rare earth industry was blessed with continuous strong state support, while the emphasis shifted from its defense utility to civilian use for economic development. Developing the industry served the state's economic and strategic interests, and the state set ambitious goals of global dominance in production, application and export. The central government

[178] Export tax rebate policy is commonly practiced in international trade in order to avoid double taxation on export goods (which are subject to import tax at the same tax rate as its domestically-produced counterparts by importing countries).

narratives of development featured both marketization (promoting industry growth and market expansion) and regulation (keeping the industry development under state control).

6.2.1 State's Development Motives

From a macroeconomic perspective, developing the rare earth industry would enable the Chinese state to get foreign currency that it desperately needed in the early years of the economic reform. According to Hong Feng, a retired government official in the State Council Rare Earth Leadership Group and later the director of the State Rare Earth Office under the State Planning Commission, "in the early years of the economic reform, there was a significant shortage of foreign currency, as the annual trade volume was less than 100 billion dollars; there were almost no industrial products that China could export in exchange for foreign currency…China mostly relied on exporting agricultural products and raw materials that foreign countries had a shortage for. Although China produced large quantities of steel, aluminum, magnesium and zinc, they were not enough for China's own consumption, let alone export. Thus rare earths were given the mission of bringing in hard currency, as the mining was fairly easy and involved low investment, and the domestic consumption was fairly small." (Cui, 2011) As the previous subsection shows, by the late 1970s China's rare earth industry had already acquired national visibility, a top-notch technical workforce, and the technology and the capacity to produce various kinds of mixed and purified rare earth products for the global market. At the same time, in the 1980s global demand of REEs shifted away from mixed rare-earths products to higher value individual high-purity products[179]. The invention of NdFeB permanent magnet in the early 1980s and its subsequent wide

[179] See USGS statistical compendium for rare earths at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/stat/

adoption in consumer electronics in the 1980s and 1990s led to great increase in market demand for REEs in western countries. (Constantinides, 2009) Thus China's abundant supply of LREEs from Baiyun-Ebo mine (already known globally as the world's largest REE deposit) as well as supply of high-value HREEs from HREE-rich ion-adsorption clay deposits in South China provided a cheap and stable alternative source of raw materials to foreign companies. In return, China was able to attract foreign investment and bring in foreign currency in order to build manufacturing capabilities and a vibrant market economy.

From a more strategic perspective, trading with the major western powers could also "cement China's strategic ties with the West" (Parks, 1981), as China sought to advance its relations with the major western powers. This was aptly illustrated by the reform leader Deng Xiaoping's speech in 1991, "There is oil in the Middle East, there is rare earth in China; China's reserves account for 80% of global known reserves, thus it has extremely important strategic significance comparable to oil in the Middle East. We must develop the rare earth industry well so that we can unleash our rare earth superiority." ("中东有石油，中国有稀土, 中国的稀资源占世界已知储量的百分之八十，其地位可与中东石油相比具有极其重要的战略意义。一定要把稀土的事情办好，把我国稀土优势发挥出来") (Baotou National Rare-Earth Hi-Tech Industrial Development Zone, n.d.)

6.2.2 State Development Narratives: Marketization with Regulation

The central government's development narrative focused on promoting rare earth industry production and marketization in order to advance its rank in global production. A key central political figure in the early years of the industry development was Vice

President of the State Council Fang Yi, Deng's close reform ally. Fang was in charge of overseeing China's science and technology development and conducted extensive research over the rare earth industry. From 1978 to 1986 Fang made personal visits to the Baiyun-Ebo mine and Baotou Steel and Rare Earth Company seven times. (Ma, 2000) Under his directive, the Ministry of Metallurgical Industry concluded that "developing and utilizing the rare earth resources in Baotou would very likely lead to China's rare earths products dominating the global market." (PRC Ministry of Metallurgical Industry, 1978) Fang set the long-term vision for the industry development as "three first-ranked in the world, including the first in rare earth production, the first in rare earth application and the first in rare earth export." (Cui, 2011) Fang also set the state strategy for the rare earth industry as "selling high volume at low cost, promoting application, increasing export, and enhancing production" (薄利多销、推广应用、扩大出口、促进生产). The narrative of state-led marketization for development was echoed in the top party leadership as well. In 1987 Wen Jiabao, then Director of the General Office of the Central Committee of the Communist Party of China, gave the party directive to "take a comprehensive view of rare earth industry development, application and export combined with China's overall S&T development strategy and economic development strategy; draft clear resource policies, industrial policies, S&T policies and trade policies which work together to help the industry contribute to fast economic and S&T development" (一定要把稀土资源的开发、利用、出口战略同科学技术发展战略、经济发展战略结合起来考虑，制定明确的资源政策、产业政策、科技政策和外贸政策，使之并行不悖地促进我国经济和科技的迅速发展). (Wen, 1987) This directive determined that under the party leadership, the rare earth industry would follow the larger macroeconomic and S&T transition towards the market economy.

Yet the state would not let the market alone play the invisible hand. Along with the theme of developing the market economy, the state narrative of development also featured prominently the state as the regulator over the rare earth industry in the transition towards the market economy. The inter-ministry Rare Earth Leadership Group reporting to the State Council continued to be the major bureaucratic body overseeing the rare earth industry development. In drafting the rare earth industry development plan of the 7th Five-Year Plan (1986-1990) in 1984, Xu Chi, then Vice Minister of Metallurgical Industry remarked that "the reserves of China's rare earth resources can definitely meet industry needs, but currently rare earth mining lacks a high-level plan and strict scientific guidance, which would likely lead to unregulated mining, resource waste and environmental pollution." (Xu, 1984) Within a year of Wen Jiabao's 1987 party directive, the State Council announced the overarching strategy for rare earth industry development as "Enhancing Regulation, Protecting Resources, Developing Scientifically, and Aligning together in International Market" (强化管理，保护资源，科学开发，联合对外). (PRC State Council Rare Earth Leadership Group Office, 1988) At the 2nd National Rare Earth Industry Conference in 1989, Ye Qing, then Vice Commissioner of the State Planning Commission and Director of the State Council Rare Earth Leadership Group [180] highlighted the issues of "blind development and repeated projects" (盲目发展、重复建设）and "multiple exporters benefiting the foreign buyers" (多头出口，废水外流) in

[180] In 1988 the "National Rare Earth Applications Promotion Leadership Group" was changed to be directly supervised by the State Council as the "State Council Rare Earth Leadership Group" (国务院稀土领导小组).

the industry. (Ye, 1989) Ye also identified five core missions for the state leadership in developing the rare earth industry in the 8th Five-Year Period (1991-1995) as "improve and reinforce national macro-level regulatory system, unify regulations and policies, strictly enforce laws"; "decrease and control investment in fixed assets, make adjustments to industry structure (revitalizing large-scale and middle-scale enterprises, while consolidating small-sized and township and village enterprises)"; "conduct state planning on rare earth production"; "enhance governance on rare earth production and technology export, ensure stable and healthy expansion of export"; and "enhance governance on resources of mining sites and protect ecological environment". (Ye, 1989)

After Deng Xiaoping's famous speech in 1992 remarking "Middle East has oil while China has rare earths", there was further emphasis from official state narratives in regulating the industry as well as ensuring the thriving market and export dominance. At the Working Meeting of the State Council Rare Earth Leadership Group in 1992, Ye Qing made the directive that "in industry governance, it is necessary to both govern well and let the market grow, to govern by the principle of combining industry planning with market regulations, and to change method of intervention from bureaucratic mechanisms to non-governmental mechanisms including industry associations." (PRC State Council Rare Earth Leadership Group Office, 1992) In 1994, Bai Jie, then Director of the State Rare Earth Office under the State Planning Commission (formerly the State Council Rare Earth Leadership Group), emphasized that the office would "change its functions and utilize primarily economic measures to regulate industry according to new market economic conditions; draft long-term plans, industrial policies, priorities in industry development, priorities in research and development of rare earth applications.” (Sui, 1994)

6.3 Industry-Specific Regulatory and Policy Changes

In accordance with the dual narratives of marketization and regulation, the state enacted a series of policies to promote as well as regulate the development of the rare earth market, industry production and trade. This section surveys major government policies, regulations and initiatives from 1978 to 1997 on production, trade and foreign investment and industry upgrading.

6.3.1 Production Promotion and Regulation

6.3.1.1 Promoting Industry Production

In order to achieve the long-term goal of global dominance in production, applications and export that Fang Yi envisioned, the state enacted ambitious high-level plans of increasing industry production capacity and product competitiveness. At the start of the economic reform in 1978, the production capacity of Chinese rare earth industry had already reached 4370 tons (in REO unit), ranking the fourth in the world. However, the industry was producing primarily low-grade products at higher costs and lower recovery rate[181] compared to foreign producers. (Xu, 1984) The state released the *1979-1981 Rare Earth Application Promotion Plan* in 1979 and subsequently the *1983-1985 Rare Earth Industry Development Plan* in 1983. (PRC State Economic Commission et al, 1979; PRC State Council Rare Earth Leadership Group, 1983) Based on these two plans, from 1978 to 1985 the State Economic Commission and the State Science and

[181] The rare earth refinement/smelting process typically yields only a small percentage of the desirable elements contained in the ore, a percentage referred to as "recovery rate". A higher recovery rate in the refinement/smelting process can lead to increase in the capacity of production and less wasted rare earth elements from the process.

Technology Commission allocated more than 70 million RMB funding to upgrade rare earth mining and production technologies in major rare earth companies and to increase funding support for research in lowering production costs and increasing industry applications. (Zhou, 1985) By 1984, the Chinese rare earth industry reached production capacity of 12000 tons (ranking the second in the world behind the U.S.) and was able to produce both large quantities of mixed rare earth products for export as well as highly-purified rare earth oxides at costs comparable to foreign producers. (Xu, 1984) The state then set the goal of increasing the production capacity to 20000 tons and production volume to 16000-18000 tons, larger than those of the United States (then the major global producer) in the 7th Five-Year Plan (1986-1990). (PRC State Economic Commission et al, 1985) This goal was achieved ahead of the deadline: in 1988 China's rare earth concentrate production volume reached 29640 tons (in REO unit), overtaking the U.S. as the largest global producer. (Ye, 1989)

6.3.1.2 Regulating Industry Production

The state introduced regulations on production from ion-adsorption deposits in South China. In September 1987 the State Economic Commission and the Ministry of Geology and Mineral Resources mandated that ion-adsorption rare earth deposits in South China were subject to regulation as "special resources". New mining projects would require approval from the provincial-level government. Without government approval, "non-PRC-citizens are forbidden to enter the mining area or access the geological and mining data". (PRC State Economic Commission & Ministry of Geology and Mineral Resources[182], 1987) In January 1991 the State Council further mandated that ion-adsorption rare earth deposits would be subject to "protective mining" consisting of the following measures: 1. The State Council Rare Earth Leadership Group would conduct mid-term and long-term planning of mineral resource and mining project development; 2. Joint venture and international collaboration in ion-adsorption rare earth mining would be prohibited; 3. New ion-adsorption rare earth mining and refining projects would be approved only by the State Council Rare Earth Leadership Group, while existing projects would go through consolidation; 4. The State Council Rare Earth Leadership Group would release production plans of ion-adsorption rare earth products to each province/autonomous region, and private enterprises would be banned from ion-adsorption rare earth mining; 5. non-state companies (including local collective enterprises, township and village enterprises, joint ventures with foreign firms, and private enterprise) would no longer be allowed to conduct ion-adsorption rare earth smelting, and existing collectively owned and private smelters would be closed; 6. The State Council Rare Earth Leadership Group would assume primary responsibility in regulating the domestic market pricing and trade of ion-adsorption rare earth products, and individual market transactions would be prohibited. (PRC State Council, 1991)

Besides restrictions on mining the ion-adsorption deposits in South China, the state also introduced restrictions on production of major rare earth primary products. Starting in 1990, production of three major primary products, Baiyun-Ebo rare earth

[182] Ministry of Geology and Mineral Resources was merged into the current Ministry of Land and Resources in 1998.

concentrates, ion-adsorption rare earth oxides, and rare earth chlorides[183] were subject to production planning and volume control to promote both export and domestic industry growth. (PRC State Council Rare Earth Leadership Group, 1989)

6.3.1.3 Shifting Regulatory Duties to Non-governmental Entities

With deepening economic reform in the 1990s, the state experimented with using non-governmental corporate alliances to help coordinate industry production among major rare earth firms. In the 1993 State Council Reform, the State Council Rare Earth Leadership Group was abolished and its regulatory and planning functions were transferred to the State Planning Commission (SPC). The Leadership Group staff members joined the newly established Rare Earth Office under the State Planning Commission（国家计委稀土办公室）. (PRC State Council Rare Earth Leadership Group, 1993) In 1994, the Association of China Rare Earth Industry (中国稀土行业协会), spearheaded by Shanghai Yaolong Non-ferrous Metals Company, was established as a national-level social organization (社会团体）. As a non-government organization registered with the Ministry of Civil Affairs, ACREI was set up to coordinate production and export volumes and pricing of its 45 corporate members. (Rare Earth Office of the State Planning Commission, 1994) The Association held annual meetings attended by representatives of corporate members as well as officials of the Rare Earth Office of the State Planning Commission, until it was abolished in 2001 for failing to complete required annual review for social organizations. (Hu, 2012)

6.3.2 Trade Promotion and Regulation

[183] Rare earth chlorides are hydrates which contain mixed rare earth elements, and are used primarily as low-cost source material from which highly enriched mixed REOs or highly purified single REOs can be extracted.

6.3.2.1 Trade Promotion

With the launch of the Reform and Opening campaign, the state acted as a strong broker for trade deals between domestic suppliers and foreign buyers. In order to promote Chinese export, government officials organized trade missions, researched foreign markets and industrial policies, attended trade fairs, accompanied domestic producers on promotional tours in foreign companies. Notable state-led initiatives to open up the international markets are as follows.

- West Germany: In 1979, the Ministry of Metallurgical Industry organized a delegation of Chinese nonferrous metal experts to visit West Germany to study the local rare earth research institutes, production plants and manufacturing companies in the rare earth industry. (PRC Ministry of Metallurgical Industry, 1979)
- Japan: In 1980, Jiangxi Tungsten and Rare Earth Trading Delegation, headed by Liu Kai, then Vice Director General of the Department of Metallurgical Industry of the Jiangxi Province Government, visited Japan to promote metal products including the ion-adsorption rare earth products. It was the first time that China’s ion-adsorption rare earth products were showcased to the international market. (Liu & Guo, 1993)
- U.S.: To open up the U.S. market, Baotou Steel Rare Earth Company attended an international trade fair in April 1983 held in Houston at the invitation of the U.S. Marine Technology Communication Center and presented 270 pieces of rare earth ores, alloys, compounds and other primary products during the

exhibition. It was the first time that Chinese rare earth products were showcased on an international exhibition. (BRIRE, 1983)

- Britain, France, U.S. and Japan: In April 1985 the Ministry of Metallurgical Industry selected a group of 13 officials to conduct research visits in Britain, France, the U.S. and Japan and study rare earth industry development in these countries. This “Chinese Rare Earth Industry Technology and Trade Research Visit Group” (中国稀土工业技贸考察团) visited in total 36 rare earth companies, research institutes, universities, downstream companies and trading companies in the four countries. (PRC Ministry of Metallurgical Industry, 1985)
- European region: In 1988 in order to promote Chinese export in the European market, the State Council Rare Earth Office and China Minmetals[184] selected a group of experts to visit Netherlands on a trade mission sponsored by the Centre for the Promotion of Imports from Developing Countries, commissioned by the Ministry of Foreign Affairs of the Netherlands. The experts visited Philips and other large companies in downstream industries, bringing English-language video materials and sample products from Chinese producers, “begging the others to buy our rare earth products.” (Cui, 2011)

[184] China Minmetals is a state-owned enterprise that was established in 1950 by the State Council to be in charge of metals import and export in the planned economy era. It continued to expand its trading business in the economic reform era, and is now directly controlled by the central government through the supervision by SASAC. China Minmetals was ranked as No. 192 in Fortune 500 Companies in 2013. For more information, see company website at http://www.minmetals.com.cn/wkjj/fzjs/

Besides these state initiatives promoting trade, the introduction of full export tax rebate policy in 1985 for all export goods (PRC Ministry of Finance, 1985) also increased the overall competitiveness of Chinese exports in the late 1980s and the 1990s.

6.3.2.2 Export Regulation

While state initiatives and tax rebate policy helped drastically increase rare earth export, the state also quickly introduced regulations on eligibility of export, technology transfer, foreign investment, export volume and pricing starting in the late 1980s.

- Export through three state-owned trading groups:

In July 1987 The State Economic and Trade Commission mandated that rare earth products would only be exported through three trading companies controlled by the central government, including China Minmetals Import & Export Company (中国五金矿产进出口总公司), China Non-ferrous Metals Import & Export Company (中国有色金属进出口总公司） and China Metallurgical Import & Export Company （中国冶金进出口总公司）[185]. (PRC Ministry of Foreign Economy and Trade[186] & State Economic Commission, 1987) These three trading groups all had local subsidiaries, and export transactions with local producers were managed by their local subsidiaries in each province. In March 1989 the State Council Rare Earth Leadership Group announced that a 3-person coordination team consisting of one representative from each of the three

[185] See the next subsection for the history and the company structure of the three companies.

[186] Ministry of Foreign Economy and Trade was established in 1982 to be in charge of foreign trade. It was reshaped into the Ministry of Foreign Trade and Economic Cooperation in 1993, and the latter was transferred to become part of the newly created Ministry of Commerce in the 2003 State Council reform.

trading groups would coordinate export prices of rare earth products. (PRC State Council Rare Earth Leadership Group & Ministry of Foreign Economy and Trade, 1989)

- Restrictions on foreign investment and joint ventures:

Starting in July 1990 further regulations on rare earth export and foreign investment were implemented: 1. Any REE-related projects involving foreign investment would require the approval from both the State Council Rare Earth Leadership and the Ministry of Foreign Economy and Trade; 2. Joint venture and foreign investment in ion-adsorption rare earth mining would be prohibited; 3. Export of rare earth mining and element separation technologies would be prohibited; 4. Joint ventures and foreign investment in rare earth smelting (separation and purification) projects must have import of advanced technology and machinery from abroad, and they must be approved only by the State Council. (PRC State Council Rare Earth Leadership Group et al, 1990) These regulations in effect shielded the industry upstream from possible foreign competition.

- Export price and quota control on specific products:

Starting in the late 1980s, the state also gradually introduced export pricing and quota control on specific rare earth products. The trend of increasing regulation was more apparent after 1989. This could be due to two reasons. Firstly, to enforce existing regulations on rare earth mining and production of specific rare earth products since the late 1980s, corresponding regulations on rare earth export would be necessary and cost-effective for the state to implement, as most rare earth products with production restrictions in China were produced for export, and the eligibility of export were controlled by state-owned trading companies. Secondly, after the Tiananmen Square incident in June 1989, the U.S. and its allies enacted economic sanctions against China, making it more difficult for Chinese companies to export their products to these countries. As a result, Chinese rare earth producers, particularly producers of ion-adsorption rare earth products in South China who relied primarily on export sales, sold overstocked products to foreign buyers at exceedingly low prices. (PRC State Council Rare Earth Leadership Group, 1989; Ma, 1995) The lackluster export demand and low export prices lasting from 1989 to 1993 provided an impetus for the state to enact control over rare earth export. Major restrictions on specific rare earth product exports were as follows.

1) Since March 1989 three types of rare earth products (Europium-rich mixed REOs[187], Yttrium-rich mixed REOs[188] and xenotime ores[189]) were subject to

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[187] Europium was in consistently high market demand to produce Europium-doped phosphors throughout the 1980s. Yttrium orthovanadate doped with Europium ($YVO_4:Eu^{3+}$) was discovered in the 1960s to emit red light and has since become the red phosphor in cathode ray tubes in color TVs. Europium-doped phosphor ($Y_2O_3:Eu^{3+}$) was used as component of the fluorescent light developed in the 1970s and later the CFLs which dominated the efficient indoor lighting market. The Mountain Pass rare earth mine in California used to be the major producer of Europium before the 1980s, but the Baiyun-Ebo mine gradually grabbed global market share as the Baiyun-Ebo deposit had richer Europium content in its ores than the Mountain Pass deposit. For more information about Europium-doped phosphors, see Yen et al. (2007).

[188] Yttrium-rich REO had been used chiefly to produce phosphor in color TVs before the mid-1980s, but its market value had a significant spike in the late 1980s after the discovery of YBCO (Yttrium barium copper oxide) in 1987. YBCO was the first material ever discovered to become superconducting above the boiling point of liquid nitrogen (77 K) at 93K. This made superconductive materials possible for mass consumption, as liquid nitrogen was a lot cheaper than liquid helium which was used prior for preparing superconductive materials. See the Encyclopedia Britannia entry for more information: http://www.britannica.com/science/yttrium-barium-copper-oxide.

[189] Xenotime's major component is Yttrium orthophosphate, which was used primarily as the source material for extracting high-valued Yttrium, and also used as sources of extracting the less abundant, high-valued HREEs including Dysprosium (used in permanent magnets), Erbium (used as colorant for glass), and Gadolinium (used in medical imaging and in making green phosphors in color TVs).

export control. (PRC State Council Rare Earth Leadership Group & Ministry of Foreign Economy and Trade, 1989)

2) Starting in October 1991 ion-adsorption rare earth product (containing high-valued HREEs) were subject to export control: the State Council Rare Earth Leadership Group would be responsible for drafting the export plan; the State Planning Commission would be responsible for implementing production plans to companies; China Minmetals Import & Export Company would be responsible for managing export contracts. (PRC State Council Rare Earth Leadership Group & State Planning Commission, 1991)

3) Starting in April 1992, rare earth chlorides were subject to export control: the State Council Rare Earth Leadership Group would be responsible for the export plan; the State Planning Commission would be responsible for implementing corresponding production plans; the China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters (中国五矿化工进出口商会，CCMMC)[190] would be responsible for coordinating minimum export FOB (Free on Board) price with the three major state-owned trading companies and two local independent trading subsidiaries in production regions (Gansu Minmetals Import & Export Company and Harbin Minmetals Import & Export Company which were granted independent export licenses). (PRC State Council Rare Earth Leadership Group Office, 1992)

[190] China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters (CCMMC) was founded in 1988 as a quasi-governmental industry association for companies from the metals, mining, petrochemical, hardware and building materials and related industries. For more information, see the CCMMC website http://www.cccmc.org.cn/

4) In April 1992 the Ministry of Foreign Economy and Trade published further regulations for all rare earth products under export control. The measures were as follows: 1. export deals would be made through the three state-owned trading groups and transactions would be managed by their local subsidiaries; 2. Minimum export FOB price would be managed by the CCMMC in coordination with the three trading groups; 3. export plans would be released by the Ministry of Foreign Economy and Trade, in consultation with the State Council Rare Earth Leadership Group; 4. Existing foreign-invested companies producing controlled rare earth products would need to apply to the Ministry of Foreign Economy and Trade for export licenses to export their own products. (PRC Ministry of Foreign Economy and Trade, 1992)
5) After the founding of the Association of Chinese Rare Earth Industry (ACREI), the CCMMC established the CCMMC Rare Earth Export Coordination Group (中国五矿化工进出口商会稀土出口协调小组) in 1997 to coordinate export minimum prices of export-controlled products with the ACREI on behalf of ACREI’s corporate members. (Hong, 2001)

6.3.3 Support for Research and Industry Upgrading

The state high-level plans for the industry development followed early reform leader Fang Yi’s long-term vision of not only first rank globally in mining production and export, but also first rank in applications. The *7th National Five-Year Plan for Rare Earth Industry (1986-1990)* made it a priority to “develop research and production of advanced rare earth applications and new materials (including phosphors, permanent magnets and lasers) for domestic consumption and export”. The plan set targets for major rare earth applications, including annual production capacity of 200,000-250,000 tons for rare earth alloyed steel products, 20,000 tons for rare earth alloyed aluminum products, 20,000 tons for REE-enabled petrochemical catalysts, 500 tons for rare earth polishing powder, 200-300 tons for REE-enabled permanent magnets, 30 tons for REE-enabled red phosphor powder and 50 tons for REE-enabled lighting powder. The plan also set the target of 200 million USD in total revenue from export of rare earth applications. (PRC State Economic Commission et al, 1985)

Besides high-level five-year planning, the central government provided robust institutional and funding support to develop both basic research capabilities and commercialization of REE-enabled advanced technologies. The Chinese Society of Rare Earths (CSRE) was established by the Chinese Association for Science and Technology in 1979 as a national-level research society for scientists and engineers working on REE-related projects [191]. The *1979-1981 Rare Earth Application Promotion Plan* and subsequently the *1983-1985 Rare Earth Industry Development Plan* provided more than 70 million RMB funding support for technology upgrading as well as basic research. By 1985 over 300 research institutes and university research centers in China were involved in research projects on REE mining, smelting and applications, including 23 research institutes within the CAS. (Zhou, 1985) In 1994 the State Planning Commission arranged a 3-million-dollar World Bank loan to be directed to the GRINM to establish the National Engineering Research Center for Rare Earth Materials[192]. In line with the reform of China's S&T development system towards market-oriented institutions, research

[191] For more information, see the introduction of the history of the CSRE at the CSRE website at http://www.cs-re.org.cn/rareearth/learnintroduce/introduction/.
[192] For more information, see the history introduction of the center at the GRINM website at http://www.grinm.com/p573.aspx.

institutes across China started going through marketization reform to become or join for-profit companies in the 1990s. In 1992 Baotou Research Institute of Rare Earths, the largest rare earth research institute in China, was disintegrated from the Ministry of Metallurgical Industry and became part of Baotou Iron & Steel Group.

The rare earth industry also received support in technology upgrading through key national high-tech R&D programs spearheaded by the SSTC. The 863 Program has been China's primary national high-tech R&D program from 1986 to develop and commercialize cutting-edge technologies of strategic importance[193]. REE-enabled NdFeB permanent magnets as well as REE-enabled NiMH batteries were selected among key projects under the "new materials" category in the 9th Five-Year Plan (1995-2000) of the 863 Program. (He, 1997) Similarly, the China Torch Program, another national initiative implemented by the SSTC to promote technology commercialization since 1988, includes the development of national and provincial High-tech Industrial Development Zones as local high-tech industry clusters[194]. Among them, Baotou Rare Earth High-tech Industrial Development Zone was established as a national-level high-tech zone specifically to develop downstream high-tech applications utilizing rare earth resources from the nearby Baiyun-Ebo region.

[193] The 863 Program was started in March 1986 with personal approval from the reforme leader Deng Xiaoping, and was implemented through three successive Five-Year Plans from 1986 to 2000. It was granted a 10 year renewal by the State Council from 2001 to 2010. For more information about the 863 Program, see the program website at http://www.863.gov.cn.

[194] For more information about the China Torch Program, see the website of the current Torch High Technology Industry Development Center under the MOST at http://www.ctp.gov.cn/ and the website of the National High-tech Industrial Development Zones at http://www.ctp.gov.cn/gxq/index.shtml.

It should be noted that while the central government policies provided favorable policies and funding support for industry upgrading, specific projects were often initiated by the local governments. Take the founding of the Baotou Rare Earth High-tech Industrial Development Zone as an example. On October 30, 1989 *Science and Technology Daily,* a state newspaper jointly sponsored by the SSTC, COSTIND, CAS and CAST, published an article by a material science researcher J. Ping Liu[195] entitled "Rare Earth Valley – High-tech Industry Sector of the 21st Century" . Liu argued that "in the near future, development and production of new REE-enabled materials would become a high-tech industry in the next several decades with huge growth prospect like the Silicon Valley in the U.S., and China should strive to use our resource advantage to develop cutting edge technologies and become the home of this revolutionary technological development, and avoid the old trap of exporting raw material to advanced countries and depending on advanced countries for imports of high-tech products." (Liu, 1989) Liu's article generated significant interest in the Science and Technology Commission of the Inner Mongolia Autonomous Region. Commission officials copied the article to nearly a hundred government officials of Inner Mongolia Autonomous Region government and Baotou prefecture-level government, and officials held discussions on the prospect of building a "rare earth valley". (Liu, 2014) Immediately Baotou Rare Earth High-tech Development Zone was established in 1990 and was granted the status of "National-level High-Tech Industrial Development Zone" in 1992. (PRC State Council, 1992)

[195] J. Ping Liu is now Distinguished Professor in Department of Physics, University of Texas at Arlington, and is also an adjunct professor at Ningbo Institute of Materials Technology and Engineering of the Chinese Academy of Sciences.

The export and foreign investment control measures enacted by the state from late 1980s also contributed to the state's goal of moving up the value chain. As the previous subsection states, since 1990 all REE-related projects involving foreign investment would need to be approved by the State Council. The state banned foreign investment and joint venture in rare earth mining; yet the state allowed foreign investment in rare earth smelting with import of advanced technologies and machinery and encouraged foreign investment and joint venture in producing downstream applications. (Ye, 1989) Thus after 1990 foreign companies could only set up local subsidiaries or joint ventures to produce advanced products in the mid- and down-stream of the industry supply chain. This incentivized domestic companies to set up joint ventures in downstream industries and also protected domestic upstream mining companies from international competition in resources. (Hong, 2001)

6.4 National-level Institutional Changes

While the state introduced industry-specific policies, high-level plans and regulations to oversee the development of the rare earth industry, political institutional changes in this period also contributed to the strong growth of Chinese rare earth industry and influenced the effectiveness of Beijing's new rules and regulations. This section analyzes the key changes in state political institutions and their influence on industry and market development in this period.

6.4.1 State Council's Bureaucratic Authority over Market Actors

6.4.1.1 Overlapping Bureaucratic Control between Central and Local Authorities over SOEs

This subsection analyzes the bureaucratic institutions governing the SOEs in the rare earth industry. In this period of 1978 to 1997, major state-owned companies in the rare earth industry were subject to the authority of one of the following four "bureaucratic management systems" (行政管理体系) as detailed below. As the analysis shows, although the SOEs were in principle controlled by the central government, there was in practice a considerable degree of overlapping administrative control over enterprise management between central and local authorities.

- Ministry of Metallurgical Industry (冶金工业部):

The Ministry of Metallurgical Industry oversaw the development of China's metallurgical industry in both the planned economy era and the economic reform era before it was abolished in the 1998 State Council Reform. Its industry focus in the planned economy era was steel production, known as "以钢为纲". In the rare earth industry, the Ministry directly supervised Baotou Steel Rare Earth Company (包钢稀土), the mining company extracting REEs ad producing rare earth products from the Baiyun-ebo Mine, through supervising its parent company Baotou Steel (包钢公司). The Ministry of Metallurgical Industry also supervised leading national research institutes in metals and materials, including Baotou Research Institute of Rare Earths (BRIRE) and General Research Institute for Non-ferrous Metals (GRINM).

With the gradual liberalization of trade in China's economic reform, the Ministry of Metallurgical Industry also established China Metallurgical Import & Export Company (中国冶金进出口总公司) as a separate state-owned "trading company for the industry" (工贸企业) to manage trade business for the SOEs under its control from 1980 until

1995[196]. China Metallurgical Import & Export Company was one of the three trading groups eligible to export rare earth products. In actual operation, while its head office （总公司）was directly supervised by the Ministry of Metallurgical Industry, each local import & export subsidiary (进出口分公司) were run by the staff at the export division of the metallurgical company established by each provincial government, essentially “one company with two names” (一套机构二块牌子)[197]. Thus although the head office directed the trade business of local subsidiaries, the bureaucratic supervision over local subsidiaries were shared between the head office and the local Bureaus of Metallurgical Industry (冶金工业局) officials in the provincial government who had primary supervisory power over the provincial-government metallurgical company.

- China National Non-ferrous Metals Industry Corporation (中国有色金属工业总公司)[198]:

[196] In 1995 CMIEC was merged into Sinosteel Trading Group (中钢贸易), a subsidiary of Sino Steel Corporation (中钢集团). Sino Steel Corporation was controlled by the Ministry of Metallurgical Industry before 1998 and its successor State Bureau of Metallurgical Industry before 1999. Since 1999 Sino Steel has been an SOE directly supervised by the central government. For more information, see its website at http://www.sinosteel.com/

[197] For example, see the description in *Guangxi Zhuang Autonomous Region Chronicles-Foreign Trade Chronicle* (Guangxi Zhuang Autonomous Region Local Chronicle Editorial Commission Office, 1996) about the establishment of the Guangxi Subsidiary of the China Metallurgical Import & Export Company in 1981 along with the establishment of the Guangxi Province Bureau of Metallurgical Industry Materials Company as “one company, two names”. Also see the description in *Guangdong Province Chronicles-Metallurgical Industry Chronicle* (Guangdong Province Local Chronical Editorial Commission Office, 1996) about the establishment of the Guangdong Province Subsidiary of the China Metallurgical Import & Export Company in 1980 along with the establishment of the Guangdong Province Metallurgical Industry Import & Export Company as “one company, two names”.

[198] For an authoritative overview of the development of the China National Non-ferrous Metals Industry Corporation in the 1980s, see Fei (1990). Fei Ziwen was the Chief Manager General of the China National Non-ferrous Metals Industry Corporation.

Due to overriding emphasis on iron and steel production, the Ministry of Metallurgical Industry transferred the supervision of almost all non-ferrous metal (metals excluding iron, chromium and manganese) mining and smelting plants to the local governments in the 1960s. (Fei, 1990, p.5) Thus at the onset of the economic reform, the central government found itself without direct control of production plants in the non-ferrous metal industries. In 1983 the Ministry of Metallurgical Industry requested the State Council to establish China National Non-ferrous Metals Industry Corporation as the overarching SOE consisting of all local production entities in non-ferrous metals production.

Though not a political entity, China National Non-ferrous Metals Industry Corporation as a national SOE had the same bureaucratic rank with the State Council ministries and was directly responsible for managing the non-ferrous metals industry for the State Council. (Fei, 1990, p.8) In each province the company set up a local subsidiary supervising all local non-ferrous metals companies. Such a centralized bureaucratic system known to industry professionals as “Non-ferrous Metals Industry System” (有色金属工业系统) was in place, until it was abolished in 1998 State Council Reform. In accordance with the development strategy of “industry combined with trade” (工贸结合)，China National Non-ferrous Metals Industry Corporation also established a second-tier company, China Non-ferrous Metals Import & Export Company (中国有色金属进出口总公司) in 1984. China Non-ferrous Metals Import & Export Company covered non-ferrous metal trade of the “Non-ferrous Metals Industry System”. Each local subsidiary of the China Non-ferrous Metals Import & Export Company managed the import and export business for the local subsidiary of the China National Non-ferrous Metals

Industry Corporation in each province. (China Non-ferrous Metals Import & Export Company, 1992) China Non-ferrous Metals Import & Export Company was one of the three eligible state-owned trading groups to export rare earth products after 1987.

For the rare earth industry, in principle almost all mining and smelting business outside of Baotou Steel and its subsidiaries should be controlled by the China National Non-ferrous Metals Industry Corporation. In actual local operation however, the local subsidiaries did not have control over all local non-ferrous metals companies. For instance, the Nanchang Subsidiary Company[199] supposedly should oversee all non-ferrous metal companies in Jiangxi Province (major province in South China producing HREEs), but only had control over major state-owned tungsten, tantalum and niobium companies[200].

- Ministry of Nuclear Engineering Industry (核工业部) & China National Nuclear Company (CNNC,中国核工业总公司):

The third bureaucratic system that oversaw part of rare earth production and research projects in China was controlled by the Ministry of Nuclear Engineering Industry and later China National Nuclear Company. China's rare earth industry had close relationship with the nuclear industry due to two reasons. Firstly, from a technical perspective, rare earth ores in China are classified as "Minerals Associated with Radionuclides" (伴生放射性矿). The rare earth concentrates contain radioactive

[199] Nanchang is the capital of Jiangxi Province.

[200] For more information, see the history of the Nanchang Company of the China National Non-ferrous Metals Industry Corporation at the website of Jiangxi Rare Metals & Tungsten Corporation at http://www.jxtc.com.cn/jituangaikuang/bainianjiangwu(dashiji). Jiangxi Rare Metals & Tungsten Corporation was formed as a provincial-government-owned SOE after the China National Non-ferrous Metals Industry Corporation was abolished in 1998 and its offices transferred to local governments.

elements including Thorium (Th) and Uranium (U) at levels higher than natural background radiation. The rare earth concentrates from the Baiyun-ebo deposit contain as much as 0.18-0.30% ThO_2. (Wang, 2008) Thus REE mining and smelting, as well as the production of highly-enriched REE products require the expertise of nuclear industry professionals to handle radioactivity. Secondly, from a historical perspective, the Ministry of Nuclear Engineering Industry's predecessor, the Second Ministry of Machine Building (第二机械工业部), supported the development of REE-enabled defense weapon technologies in the planned economy era. The Second Ministry of Machine Building oversaw China's nuclear sector from 1958 to 1982 and worked closely with the PLA and the NDSTC in supervising military-affiliated nuclear industry plants and military research programs.

China National Nuclear Company grew out of the split of the Ministry of Nuclear Engineering Industry in the State Council reform in 1988. Ministry of Nuclear Engineering Industry oversaw China's nuclear industry development from 1982 until it was abolished in 1988. After the abolishment of the Ministry of Nuclear Engineering Industry in 1998, its administrative functions of supervising the nuclear market were absorbed by the State Planning Commission, though on the surface the administrative duty was transferred to the short-lived Ministry of Energy (能源部) in 1988-1993. [201] The industrial plants controlled by the Ministry of Nuclear Engineering were transformed into

[201] The Ministry of Energy was established in the 1988 State Council Reform to merge the administrative functions of four energy-related ministries, Ministry of Nuclear Industry, Ministry of Petroleum Industry, Ministry of Hydro Power, and Ministry of Coal Industry. It was abolished in 1993 due to the lack of administrative power, as it had no authority over the SOE spin-offs from the previous four ministries independently controlled by the State Council, as well as no control over industry pricing and investment which were then still governed by the State Planning Commission. (Lin, 2012)

one SOE, China National Nuclear Corporation (中国核工业总公司) in 1988. As an SOE directly supervised by the central government, China National Nuclear Company enjoyed ministry-level rank in the political system[202].

The China National Nuclear Corporation had supervisory power over a few production plants with REE separation and production lines as well as military research institutes with rare earth research programs. (Rare Earth Office of the China National Nuclear Company, 1995) Notably one nuclear plant, Baotou 202 Plant (包头 202 厂) started producing rare earth metals, phosphors and permanent magnets from the Baiyun-ebo rare earth concentrates since 1988. In the 8th Five-Year (1990-1995) period, China National Nuclear Corporation devoted 13.8 million RMB to rare earth research programs and 14 million RMB to technology upgrading of rare earth production facilities. (Rare Earth Office of the China National Nuclear Company, 1995)

- China Minmetals Import & Export Company (中国五金矿产进出口总公司):

Though not a rare earth production company, China Minmetals deserves independent analysis as an important SOE in China's rare earth industry. China Minmetals Import & Export Company (中国五金矿产进出口总公司) was established by the Ministry of Foreign Trade (对外贸易部) in 1950 as an SOE monopolizing the import and export of metal products. Technically speaking, China Minerals was an independent SOE directly reporting to the State Council. In actual business operations and bureaucratic appointments, China Minmetals was part of the monopolistic foreign trade system maintained by the Ministry of Foreign and Economy and Trade in the

[202] For more information about the history of the nuclear industry development and CNNC in China, see the review of 60 years of nuclear industry development at the China National Nuclear Corporation website at http://www.cnnc.com.cn/tabid/910/Default.aspx

planned economy era and since 1982 its successor Ministry of Foreign Trade and Economic Cooperation (对外经济贸易合作部).

China Minmetal's trading business significantly declined in the 1980s. The central government gradually scraped the Ministry of Foreign Economy and Trade Cooperation's monopolistic power over import and export rights. China Minmetals faced strong competition from new metal trading groups backed by two other bureaucratic systems with ties to the Ministry of Metallurgical Industry, China Non-ferrous Metallurgical Industry Company and China Metallurgical Import & Export Company. [203]

The 1988 "Reform of the Foreign Trade Institution" (外贸体制改革) further forced all local subsidiaries of the SOEs belonging to the foreign trade system of the planned economy era to become independent local trading companies with no ties to the head office. (PRC Ministry of Foreign Trade and Economic Cooperation, 1988) Thus China Minmetals Import & Export Company lost supervisory power of all its local trading subsidiaries to the local governments. China Minmetals was able to retain its staff at head office. China Minmetals established a group of second-tier companies with staff members from each bureau of the head office and started acquiring metal production companies to complement its trading business. (Zhou, 2005)

<u>6.4.1.2 Devolution of Bureaucratic Authority on Local Economic Affairs</u>

Besides the overlapping of bureaucratic control between central and local authorities over SOE management in the rare earth industry, another important factor within state political institutions influencing the state-industry relationship in this period

[203] For more information about the history of the development of the China Minmetals Import & Export Company in the economic reform, see a review of the company's 60 years of history from 1950 to 2010 on the China Minmetals Corporation website at http://www.cmreltd.com/news/qydt/2013/03/18/975w1363593158.html.

concerned the devolution of bureaucratic authority on local economic affairs. This subsection analyzes the devolution of bureaucratic authority on economic matters and its influence on industry development in local regions.

With the gradual dismantling of the central planning in the Reform and Opening Campaign, local governments were granted the authority of reviewing and approving new local industrial projects and supervising local companies except those that were directly controlled by the central government. (Huang, 1996, p.656) The devolution of authority over project approval granted the local government significant leeway in developing rare earth mining and smelting projects in their own regions. In China the state owns the minerals and the government grants mining project to specific companies or individuals[204]. The PRC Constitution Article 9 states that “mineral resources, waters, forests, mountains, grasslands, bare lands, wetlands and other natural resources are all owned by the state.” The PRC Constitution Article 10 states that “land is owned either by the state or by public collectives.” Yet in actual practice, as marketization began to take shape in China in the late 1970s and early 1980s, mining was conducted not only by state-owned mining enterprises (国营矿山), but also by local rural mining cooperatives (集体联办矿山) and individual mining persons (个人采矿者) who then sold the ores to state-owned non-ferrous metal companies or directly to local smelting companies. In addition, in the early and mid-1980s then central Party leader Hu Yaobang[205] waged a policy campaign of developing mining to alleviate poverty in poor regions, with slogans

[204] This is different from the U.S. where the owner of the surface land also owns the right to extract minerals from underneath the land.
[205] Hu Yaobang was the General Secretary of the Communist Party of China from 1982 to 1987. Hu was a liberal-leaning leader and was credited with implementing many market reform policies in the 1980s.

of “Larger Production at Big Mines, More Open Production at Small Mines, Swifter Extraction of Available Resources” (大矿大开，小矿放开，有水快流) and “State, Cooperatives and Individuals All In” (国家、集体、个人一起上). (Li, 1984) Thus before investment and production regulations on the rare earth industry were introduced starting in the late 1980s, local governments could add new mining, smelting and applications projects quickly, facilitating the expansion of local industry capacity. Under Hu’s campaign, local companies all rushed into mining and smelting for quick profits, often even without appropriate project reviews and approvals as long as local governments allowed their projects to operate. (Hu et al, 2010)

The introduction of the *Mineral Resources Law of the People’s Republic of China* in 1986 established the institution of mining rights (矿业权) in China and closed the legal loophole for unlicensed mining. The Mineral Resources Law legislated that “state ownership of mineral resources, either near the earth's surface or underground, shall not change with the alteration of ownership or right to the use of the land which the mineral resources are attached to”[206]. The Mineral Resources Law required the mining companies to acquire mining rights in the form of mining licenses from the state, including both exploration rights (探矿权) and extraction rights (采矿权)[207]. Rural cooperatives and individual mining persons also had to acquire mining licenses (采矿许可证) from the state to conduct mining activities in compliance with the law. Before rare earth mining

[206] See the fulltext of the Mineral Resources Law of the People’s Republic of China at http://www.china.org.cn/english/environment/34342.htm

[207] These mining companies constitute the primary tier market (初级市场）for mining rights, and were not allowed to trade mining rights with other companies legally before 1996. The 1996 Amendment allows limited transfer of mining rights to other companies, which now constitute a second tier market (二级市场) for mining rights.

were subject to state control, local companies could obtain mining licenses from the local Bureaus of Geology and Mineral Resources at local governments. After state control over mining ion-adsorption deposits in South China was introduced in 1991, local companies mining such deposits had to seek approval from the Rare Earth Leadership Group under the State Council (prior to 1993) /State Economic Commission (after 1993) and obtain mining licenses from the Ministry of Geology and Mineral Resources.

Besides the devolution of authority over project approval and company supervision, the devolution of authority over tax and budget from 1978 until the "Tax Sharing Reform" (分税制改革) in 1994 also incentivized local governments to expand local industry production and trade. In the planned economy era the central government set spending priorities and approved local budgets. Taxation was primarily levied on state-owned enterprises (SOEs), with no personal or corporate income tax or resource tax. A revenue sharing system allowed the central government to redistribute collected revenues to fund local expenditures of less developed regions. In the reform era, the revenue sharing system gradually broke down with dwindling central government revenues due to the decline of the state sector in the economy. Local governments had primary authority over local budgets, and they increasingly had to bear the primary burden of financing the budget with local revenues. (Wong, 2000, p.5) At the same time, lagging tax administration allowed businesses of many rapidly growing non-state entities to be untaxed or undertaxed by the central government, including exports, foreign direct investment and extraction of natural resources. (Wong, 2000, p.6) The 1996 Amendment to the *Mineral Resources Law of the People's Republic of China* legislated that mining companies must provide compensation to the state through resource tax (资源税) and resource compensation fee (资源补偿费). Before this amendment was enacted, mining companies did not have to pay resource tax or compensation to the central government. Given no resource compensation to the central government and the acute need to generate revenue to cover local expenditures, rare earth mining and smelting usually became the foremost options of developing the local economy for local cadres in regions with the resources. (Su, 2009) Combined with strong state support for the rare earth industry development and low market entry barrier, such institutional changes provided authority as well as incentive for local governments to rapidly expand the local rare earth industry capacity.

6.4.2 Changes in Local Cadre Management System

Internal institutional changes in China's cadre management system also had indirect influence on state-industry relationship and contributed to the rapid expansion of rare earth industry. The Department of Organization (DOO) under the Central Committee of the Communist Party of China (中共中央组织部) is the primary agency in charge of managing cadres and party members in China. Before 1983 the DOO followed a "two-level downward" (管理下两级机构）model where the party authorities managed cadres at the next two lower levels. (Department of Organization of the Central Committee of the Communist Party of China, 1980) Thus the Central Committee not only directly appointed central ministry-level and bureau-level cadres and chief management personnel of SOEs, but also directly appointed local party leaders and cadres at both provincial (省、市、自治区）and prefecture (市、州、盟） levels. Such a system was crucial to administrative centralization in the planned economy era. (Xin, 1984)

6.4.2.1 "One-level Downward" Cadre Management

Since 1983, the DOO has switched to a “one-level Downward” (下管一级) model where the party authorities would only appoint and remove cadres at the next lower level. (Department of Organization of the Central Committee of the Communist Party of China, 1983) For local authorities, the central party committee would only appoint provincial-level cadres; local party committee of each administrative level would appoint cadres at the immediate lower level. This change in cadre management system was designed to increase efficiency in administrative appointments and decision making. In practice greater local authority in personnel management led excessive nepotism and concentration of decision making within local governments. (Manion, 1985)

To curb localism and nepotism in cadre promotion, the DOO has implemented “dual management” (双重管理) since 1991 complementing the “one-level downward” model. (Department of Organization of the Central Committee of the Communist Party of China, 1991) Central bureaus in key areas of governance would manage the local bureaus personnel jointly with the local party committee of the corresponding level. According to He (2013), customs (海关）, quarantine inspection (检疫） and national taxation（国税） have been under “vertical management” (垂直管理)， meaning the central ministries/bureaus have primary power of managing personnel at all local bureaus. Security (安全）and local taxation (地税）have been under “vertical management below the provincial level”, meaning that the provincial-level local bureaus directly manage personnel of local lower-level bureaus. Most other governance areas, including major ones critical to industry development, such as construction (建设）, finance (财政）, industry and commerce (工商), land and natural resources (国土), party organization (组织), supervision (监察) and auditing (审计) have been under “Kuai Kuai (Horizontal)

Management" (块块管理). The local party committee has major power over personnel management in local government bureaus of these areas; the ministry/bureau of the immediate higher level in the administrative hierarchy has supplemental power in personnel management. In personnel appointment of local bureaus, Local party committee need to consult with the corresponding higher-level ministry/bureau. (He, 2013) In actual practice in the 1990s, "dual management" of personnel in these "Kuai Kuai Management" bureaus were less than successful. In some regions it became practically just local-level personnel management, because higher-level bureaus were not informed of appointment decisions, or were reluctant to carry on the burdening of reviewing local personnel performance and appointments; In some other regions it became two separate rounds of personnel reviews by the higher-level bureaus and the local party committees rather than joint decision making. (Yang, 1996) In Fujian Province for instance, as much as 30% of local industry and commerce bureau cadre appointments did not involve the higher-level industry and commerce bureaus. (Yang, 1996) Therefore under "dual management" local party committees/governments still had considerable power in cadre management in areas of governance that were critical to industry development.

6.4.2.2 Cadre Evaluation Biased towards Local Economic Performance

The criteria for cadre performance evaluation and promotion is an important factor in cadre management. In the 1980s and the 1990s the performance evaluation in annual local cadre reviews[208] and in cadre promotion decisions relied heavily on local

[208] DOO started imposing regular review of cadres in 1979, and formalized the scheme of annual reviews of local cadres by local governments in 1988. (Department of Organization of the Central Committee of the Communist Party of China, 1988)

economic growth statistics. Strong figures such as high local GDP and revenues, strong investments and high employment became the fast track to get promoted, whereas other aspects of development such as project success rate, public infrastructure and environmental record were less emphasized. (Jiang, 2003) Competition between cadres of different regions resembling a “promotion tournament” (晋升锦标赛）could determine the promotion or termination of a cadre’s tenure; therefore local cadres were in fierce competition to bring as much industry projects and investment to their own regions as possible. (Hu, 1997; Quan, 2003; Zhou, 2007)

It should be noted though that such bias in cadre review and promotion was consistent with the overall emphasis of the state on high-speed economic development. In the 7th Five-Year Plan (1986-1990), the State Council led by then Premier Zhao Ziyang put 44% GNP growth and 35% trade value growth in five years as the primary goal in economic development. (Xinhua, 2005a) In the 8th Five-Year Plan (1991-1995), the State Council led by then Premier Li Peng put 6% annual GNP growth as the primary goal (Li, 1991). In the 9th Five-Year Plan (1996-2000) and the 2010 Vision Plan, the State Council led by Li Peng declared the goal of “doubling the GNP level of Year 1980 by Year 2000” and “doubling the GNP level of Year 2000 by Year 2010.” (Xinhua, 2005b) In accordance with the central five-year plans, many local governments at provincial and prefecture levels put GDP/GNP growth (usually double digit annual growth) as the primary target in local five-year plans.

This institutional handling of career rewards and punishments based on economic output and investments created additional incentive for local cadres to expand local industry production, investment and export. As cadre promotion was usually a zero-sum game between local cadres of the lower level, it also led to widespread protectionism in order to guarantee profits of local companies, duplication of investment and industry projects across regions, as well as underselling of land and resources in order to attract investment. (Quan, 2003; Zhou, 2004) When central authorities imposed regulations on industry output and investment, local government cadres in some regions intentionally created fraudulent local industry statistics to satisfy regulations, while still extending protection to non-compliant practices in the local industry in order to maintain high economic growth and local employment. (Chen, 1994)

6.4.2.3 Cadre Monitoring and Evaluation

The central government established auditing and discipline inspection institutions to monitor and evaluate the performance of central ministries and local governments, yet their effectiveness was still constrained by issues in "dual management" cadre system. The State Council established the State Auditing Administration (审计署) in 1983 to audit and supervise state finances, including finances of all other ministries. Local auditing offices were also established to audit and supervise finances of local governments. (Yi, 2002) The State Council also re-established the Ministry of Supervision (MOS, 监察部）in 1987 to monitor the conduct of cadres and discipline cadres with illegal conduct. Since 1993 the Ministry of Supervision and all local bureaus of MOS have had joint office (合署办公） with the CPC Central Commission for Discipline Inspection (中共中央纪律检查委员会）and all its local discipline inspection commissions as one single political entity for discipline inspection and inspection[209]. The

[209] For more information, see the website of the CPC Central Commission for Discipline Inspection – State Council Ministry of Supervision at http://www.ccdi.gov.cn/.

Discipline Inspection and Supervision Institution (纪检监察体制）included the central committee, local bureaus of supervision/commissions of discipline inspection at each local level of bureaucracy, as well as offices of discipline inspection in SOEs, public institutions and social organizations.

Because the auditing and supervision departments were subject to “Kuai Kuai Management” in dual management, local cadre supervision and finance auditing were unlikely to be highly effective. The local inspecting and auditing personnel were primarily managed by the local party committees, resulting in the conflict of monitoring the performance of local cadre who would manage their own personnel appointment, thus an inherent incapability of good monitoring. (Dong, 1998) In addition, the administrative expenditures of performing cadre inspections and financial audits were borne by the local government. The inspectors and auditors were made hostage to dwindling local government expenditures in poor regions, and they often lacked support from the local government if unfavorable results were presented to the higher level. (Yi, 2002) Therefore, non-compliance of central policies and regulation was hard to be detected.

6.4.3 Intellectual Property Rights Laws Promoting Technology Transfer

Finally, a key political institution that influenced development in the rare earth industry in China was the unique intellectual property rights (IPR) institution in China in the 1980s and the 1990s. When the economic reform started in 1978, there were no institutions in China protecting the IPR, as the state claimed rights to all technology resources and the notion of private property did not exist.

The *Patent Law of the People’s Republic of China* was introduced in 1984 and implemented in 1985. (PRC National People’s Congress, 1984) This 1985 Patent Law differed from patent regulations adopted in western countries in several aspects discussed below.

1) The patent law was designed by the state to not only "protect the legitimate rights of the patentee and encourage creations and innovations", but also "advance the application of inventions and creations, enhance innovation capability and promote the progress of science and technology and the development of economy and society"[210]. This Article remains to be the Article 1 of the current PRC Patent Law. Thus the fundamental goal of the state in implementing IPR protection was not to build and reward a privileged group of inventors and set up a high bar for market entry, but to promote the adoption of new technologies for economic development.
2) Unlike most western countries in which patents strictly belong to an individual or one enterprise, the 1985 Patent Law stipulated in Article 14 that "Where any patent for invention, belonging to any state-owned enterprise or institution, is of great significance to the interest of the State or to the public interest, the competent departments concerned under the State Council and the people's governments of provinces, autonomous regions or municipalities directly under the central government may, after approval by the State Council, decide that the patented invention be spread and applied within the approved limits, and allow designated entities to exploit that invention. The exploiting entity shall, according to the regulations of the State, pay a fee for exploitation to the patentee. Where any patent for invention, belonging to any cooperative

[210] Excerpts of Article 1 of the PRC Patent Law of 1985.

enterprises and individuals, is of great significance to the interest of the State or to the public interest, the same rule applies after request by relevant State Council ministries and approval by the State Council. "[211] This article essentially created legal space for state-owned companies, state-affiliated research institutes, cooperative enterprises and individuals to share patented technologies with each other for a usage fee. According to then Head of the PRC Patent Bureau Huang Kunyi, this article in practice also banned the state-owned companies and research institutes from withholding transfer of technologies to other state-affiliated entities in industries considered to be of significance to the state. (Huang, 1983) This Article was only amended in 2008 to remove the clause concerning cooperative enterprises and individuals. (PRC National People's Congress, 2008) It was not fully removed until the 2010 Amendment to the PRC Patent law. (PRC State Council, 2010a)

3) The 1985 Patent Law did not give patent right holders the right to ban other companies or individuals to import patented technologies or products made with patented technologies. This was only granted in Article 11 of the 1992 Amendment to the Patent Law. (PRC National People's Congress, 1992) The absence of the right to exclude imports of a patented product in the 1985 Patent Law allowed parallel imports for Chinese companies and thus promoted the adoption of advanced foreign technologies in China. It also prevented the possibility of one single Chinese company or one single foreign company subsidiary from monopolizing imported technologies.

[211] Excerpts of Article 14 of the PRC Patent Law of 1985.

4) The 1985 Patent Law ruled that the time limit of protection of invention patents in China is 15 years, and for product design patents the time limit is 5 years with a 3-year extension available pending application[212]. This was less than the 20-year limit common in most western countries. The 1992 amendment changed the limit to 20 years for invention patents and 10 years for design patents. It should be noted though that in drafting their first patent laws, most less-developed countries adopted time limits of patent protection shorter than the time limits allowed by patent laws in advanced western countries, thus China was following the norm. (Zheng, 1984)

These legal differences promoting domestic transfer among state-affiliated market actors and the import of advanced foreign technologies were vital to the expansion of rare earth production in China. In addition, the relaxed enforcement of IPR in China failed to assign rights where they were necessary. There was little awareness of IPR among Chinese scientists and engineers, and infringement of intellectual property was not strictly persecuted. This resulted in almost free transfer of advanced rare earth technologies across the industry. As Prof. Xu Guangxian illustrated, "in the 1980s and the 1990s, scientists thought that since our funding for research came from the state, our R&D products would also be provided free of charge to state-owned companies. The plan at that time was to only promote our rare earth separation technology in the three state-owned rare earth companies, Baotou Steel & Rare Earth Company, Shanghai Yaolong Chemical and Guangdong Zhujiang Rare Earth Processing Plant. Because of the cost of entry for rare earth industry at that time was very low, and the profit margin was very

[212] Excerpts from Article 45 of the Patent Law of 1985.

high, many local-government-controlled companies and private companies also started operation. The state-owned companies had low wages, whereas local companies and private companies offered very high wages, and some senior engineers were hired by these companies. They took all the technologies with them." (Ouyang, 2009) This almost free flow of advanced technologies provided huge cost advantage to the rare earth industry in the early period of development. Yet on the other hand, the lack of strong institutional protection of IPR hindered the shift of R&D responsibility towards the corporate sector, part of the state-driven marketization process of China's S&T institutions. According to a report by the Bureau of Intellectual Property of the Inner Mongolia Autonomous Region Government, most domestic rare earth companies were reluctant to contribute significant revenues to investment in cutting-edge R&D, as new technologies were quick to be copied by other companies. (Li, 2005)

Aside from these broad institutional differences affecting industry production, one specific difference in China's IPR law compared to the IPR laws of Japan and the U.S. unexpectedly changed the market dynamic for rare earth permanent magnets in China. The PRC Patent Law stipulates that the "right of priority" (优先权) for patent filing for technologies which are already published or awarded patents outside of China would extend to one year in maximum, even when the filers are the same institution/individuals[213]. This no exemption rule was designed to follow the European Patent Convention, instead of the rules in U.S. and Japan which allowed exemption from the rule for the same institutional/individual patent filer. (Sundial Intellectual Property Law Firm, 2014) This difference, when applied to the rare earth permanent magnets, led

[213] See Article 22 of the PRC Patent Law.

to foreign companies unable to capture the rapidly growing Chinese market exclusively. The Japanese company Sumitomo Special Metals Corporation (SSMC) and the U.S. company Magnequench (MQ) independently invented the techniques of producing sintered NdFeB magnetic powder in 1982. The two companies filed patents to produce and sell sintered NdFeB magnets in the U.S., Japan and Europe in 1983, and they reached a cross-licensing agreement on patent rights. When the Patent Law started to be implemented in China in 1985, both SSMC and MQ applied for patents for the NdFeB magnetic powder in China. Yet because 1985 was already two years after 1983, the patent applications from both SSMC and MQ were rejected on the ground of no right of priority. (He & Wang, 2007) This coincidental time lag prevented SSMC or MQ to claim exclusive rights over the production or sales of NdFeB magnets in China. As a result, Chinese companies were able to produce or sell NdFeB magnets within China, although they were prohibited from selling their products to Japan, Europe or the U.S. without paying licensing fees to the patent holders.

6.5 Industry Development Outcomes

The previous sections analyze the macroeconomic environment and the various components of state reregulation in industry and market development, including reregulation goals and narratives, industry-specific policies and regulations, as well as political institutional changes from 1978 to 1997. This section analyzes the outcomes of state reregulation in comparison with the state’s goals and policy targets. Industry development outcomes are assessed in four areas: industry production, international trade, market structure and environmental and social impact.

6.5.1 Industry Production

6.5.1.1 Mine Production

China's rare earth mining output has advanced to a dominant position in global production in the merely twenty years from 1978 to 1997. According to then Vice Director of the State Planning Commission Ye Qing, China's rare earth mining production increased from 66 tons in 1980 to 8500 tons in 1988, an increase of 127 times in merely 8 years. (Ye, 1989) Figure 26 presents China's output of rare earth concentrates[214] (稀土精矿) relative to the U.S. (previously the major producer in the world) and the rest of the world from 1987[215] to 1997[216]. China's production volume of

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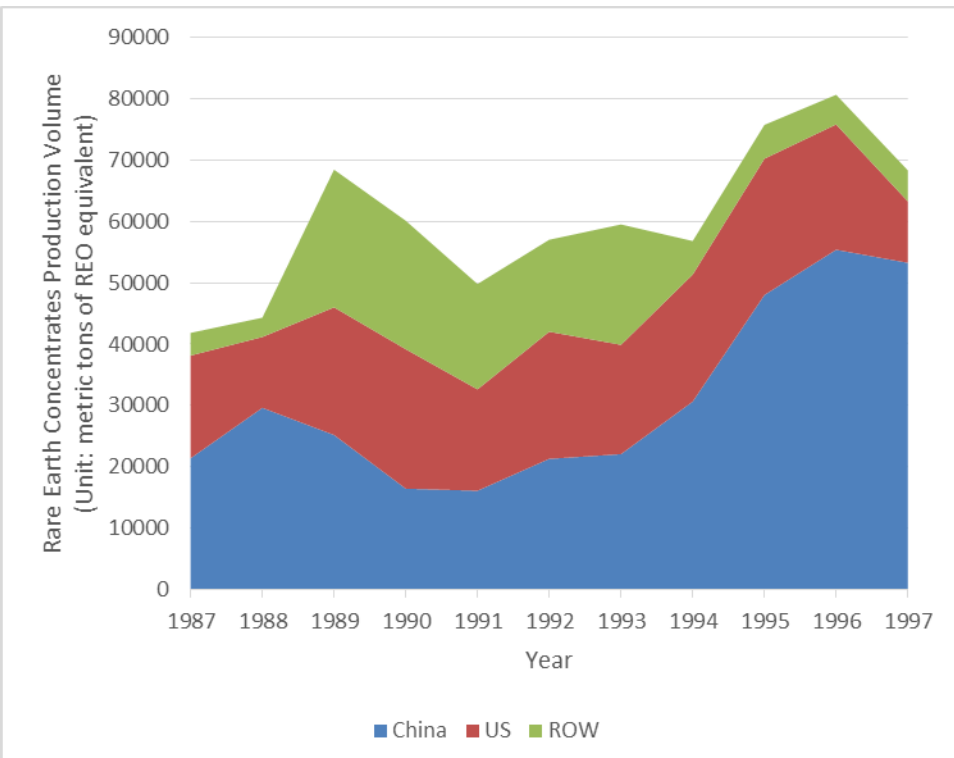
[214] Production volume of rare earth concentrates in the metric of REO tons is usually used by geologists as a metric for rare earth mining production, as the statistic measures the output of ores that have gone through refinement process which removed other coexisting metals and impurities, but have not been smelted or processed into rare earth products. Using the REO unit allows the calculation to be consistent in the chemical forms across different kinds of rare earth concentrates, making the calculation standardized for comparison across products and countries. In official calculation by the State Council Rare Earth Leadership Group, rare earth concentrates include ores from the Baotou Baiyun ebo Mine (包头精矿), ionic-adsorption REOs in South China (离子型混合稀土氧化物), bastnasite deposit in Shandong Province (山东氟碳铈矿), as well as monazite deposits (独居石), xenotime deposits (磷钇矿) and REE-rich tailings (稀土富渣). Production volume of rare earth concentrates is also sometimes referred to in Chinese as "production volume of rare earth ore products" (稀土矿产品产量). It is necessary to differentiate it from another commonly used statistic, production volume of rare earth products (稀土商品产量/稀土产品产量), which measures the volume of rare earth products in commercial forms (in REO ton units or in short ton units). The latter is often used by industry analysts to determine the amount of rare earths available on the market for immediate consumption or stockpiling.

[215] There was no official statistics of production volume of rare earth concentrates before 1987. The National Rare Earth Leadership Group was established in 1986, when its predecessor, National Rare Earth Application Promotion Leadership Group was disintegrated from the Ministry of Metallurgical Industry and became affiliated with the Bureau of Heavy Industries under the State Economic Commission. The Group started reporting production volume of rare earth concentrates in *the Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评) in 1987. Some industry publications have mistakenly used another statistic, production volume of rare earth products (published annually in relevant ministry/official publications since 1978) as the statistic for rare earth concentrates.

rare earth concentrates was already larger than the U.S. in 1987. In 1988 China's production volume of rare earth concentrates (29,640 tons in REO unit) accounted for 66% of global rare earth concentrate output, surpassing the highest annual production volume of the U.S. in history (25,314 tons in REO unit in 1984). Although China's mining output stagnated in 1989-1992, after 1994 China's output grew to encompass over 60% of global production volume of rare earth concentrates. In 1997 China's rare earth concentrate output accounted for 78% of global output.



[216] Chemical processing at the Mountain Pass Mine, major U.S. rare earth mine was stopped in 1998 after wastewater leaks. Thus after 1998, there was no new production of rare earth concentrates in the U.S.

Figure 26 Production Volume of Rare Earth Concentrates by China, U.S. and the Rest of the World (ROW) in 1987-1997[217]

6.5.1.2 Smelting Production

China has also become the world's leading producer of rare earth smelting products. Figure 27 shows China's production volume of rare earth smelting products[218] (稀土冶炼分离产品, also often referred to simply as "rare earth products"), rising from merely 1000 tons in 1978 to 46500 tons (excluding permanent magnets and fluorescent materials) in 1997. Besides China, other countries with sizable rare earth smelting production included Japan, France and the U.S. A comparison can be made between China and another major rare earth smelter, Japan. As Figure 28 shows, China's production volume increased at a much faster rate than Japan; by 1997, China's production volume was almost 10 times of Japan's production volume. It is difficult to estimate the global production volume of rare earth smelting products, as the U.S. and France do not publish their national production statistics.

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[217] China statistics are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评) published by the Rare Earth Leadership Group in the central government (the exact name of the group went through several changes due to affiliation with different ministries/commissions over time) from 1987 to 1997. U.S. rare earth concentrate production statistics are extracted from the *Minerals Yearbooks* published every year by the U.S. Bureau of Mines, and later by the U.S. Geological Survey after the closure of U.S. Bureau of Mines in 1996. Rest of the World rare earth concentrate production statistics are calculated by subtracting the volume of China's production and U.S. production from total global production volume of rare earth concentrates. The total global rare earth concentrate production volume statistics are extracted from the Minerals Yearbooks published by the U.S. Bureau of Mines/U.S. Geological Survey.

[218] This statistic is also referred to as "production volume of rare earth products" (稀土产品产量) or "production volume of rare earth smelting and processing products" (稀土冶炼分离产品产量) in the *Annual Reviews of Chinese Rare Earth Industry*. This statistic is often used to measure the production volume of the rare earth industry in a country, as it measures the production volume of products that can be used in industrial processes to produce more complex components in which rare earths are not the major compound.

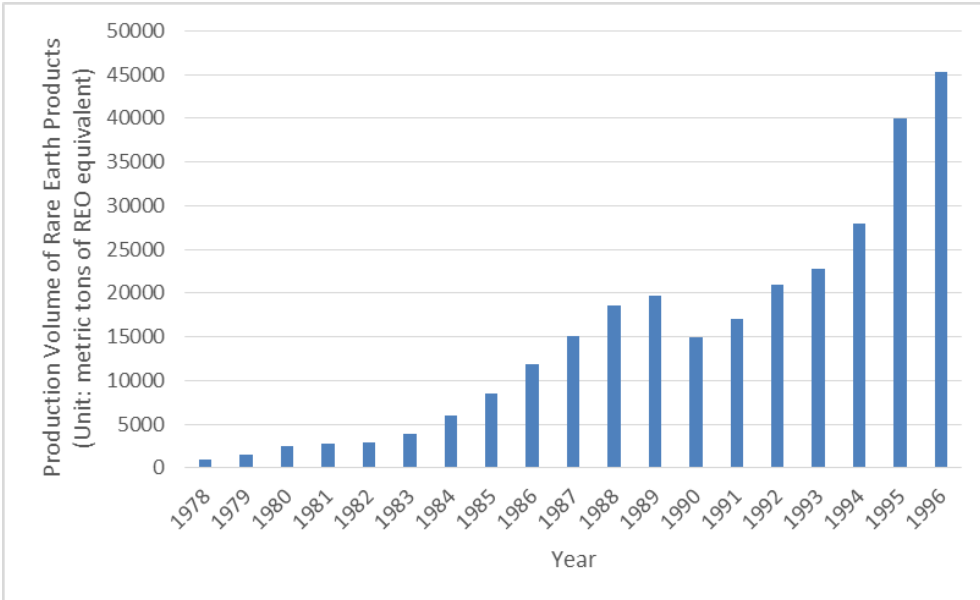

Figure 27 China's Production Volume of Rare Earth Smelting Products (1978-1996)[219]

[219] China statistics are extracted from the *China Society of Rare Earths Yearbook 2007* (中国稀土学会年鉴 2007) and the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评) from 1986 to 1996. Before 1996 China's calculation of production volume of rare earth smelting products included Samarium Cobalt rare earth permanent magnets and rare earth fluorescent materials. After 1996 rare earth permanent magnets and rare earth fluorescent materials were counted separately. Thus this graph only presents data until 1996.

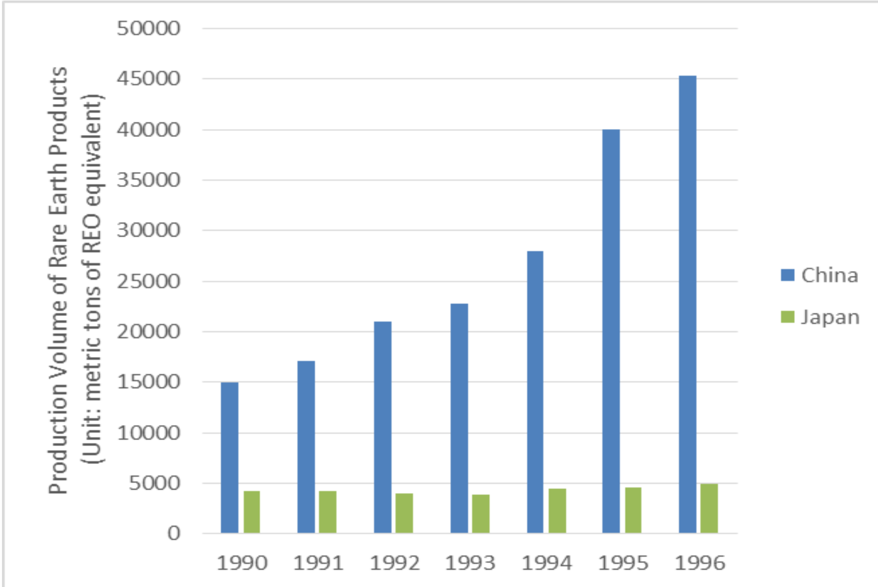

Figure 28 Production Volume of Rare Earth Smelting Products by China and Japan (1990-1996)[220]

6.5.1.3 Production of Higher-value Products

Overall speaking, although the majority of rare earth smelting products produced by China were still primary products with fairly low market value, the production of higher-value products was growing rapidly. In rare earth smelting products, China had rapidly growing production of higher-value separated rare earth products including individual rare earth oxides and individual rare earth metals. In the 1980s, the production volume of individual REE products increased dramatically from only 20 tons in 1980 to 1160 tons in 1988 (in REO equivalent) (Ye, 1989), while it was still small compared to the overall smelting products production volume of 18600 tons (in REO equivalent). As

[220] China statistics are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评) from 1990 to 1996. Japan statistics are extracted from Su (2009, p.90), which was originally from the China Rare Earth Net database based on data reported by the Ministry of International Trade and Industry of Japan.

Figure 29 shows, by the late 1990s the production volume of individual REE products had grown to account for almost half of the total production volume of rare earth smelting products.

China's production of REE permanent magnets (including Sm-Co PM and NdFeB PM) was also rapidly growing. As Figure 30 shows, China's total production volume of rare earth permanent magnets grew from merely 28 tons in 1986 to 3150 tons in 1997, an increase of over 100 times in just a decade. Among different kinds of permanent magnets, NdFeB permanent magnet had a rapidly growing global market in the 1990s, yet only a few Chinese producers were able to pay exorbitant licensing fees to the patent holders MQ and SSMC/Hitachi[221] to produce the product for export to the global market (see Figure 31 for the comparison of Chinese and Japanese production volume of sintered NdFeB permanent magnets). To increase the export market of NdFeB magnets, Beijing Zhongke San Huan High-tech Company, a spin-off company of the Chinese Academy of Sciences, joined forces in 1995 with the China Nonferrous Metals Import & Export Company to acquire 100% ownership of MQ (Magnequench), the U.S. firm with cross-license patent agreement with Hitachi[222]. The acquisition of MQ from its parent company General Motors was the first overseas acquisition by a Chinese rare earth company. The acquisition allowed Zhongke San Huan to access the global market for sintered NdFeB magnets. (Rare Earth Office of the State Planning Commission, 1995)

[221] SSMC (Sumitomo Special Metals Co.) known as NEOMAX is now part of Hitachi Metals.
[222] SSMC and MQ (Magnequench) independently invented the techniques of producing sintered NdFeB powder in 1982. The two companies have filed patent in different jurisdictions and reached cross-license agreement.

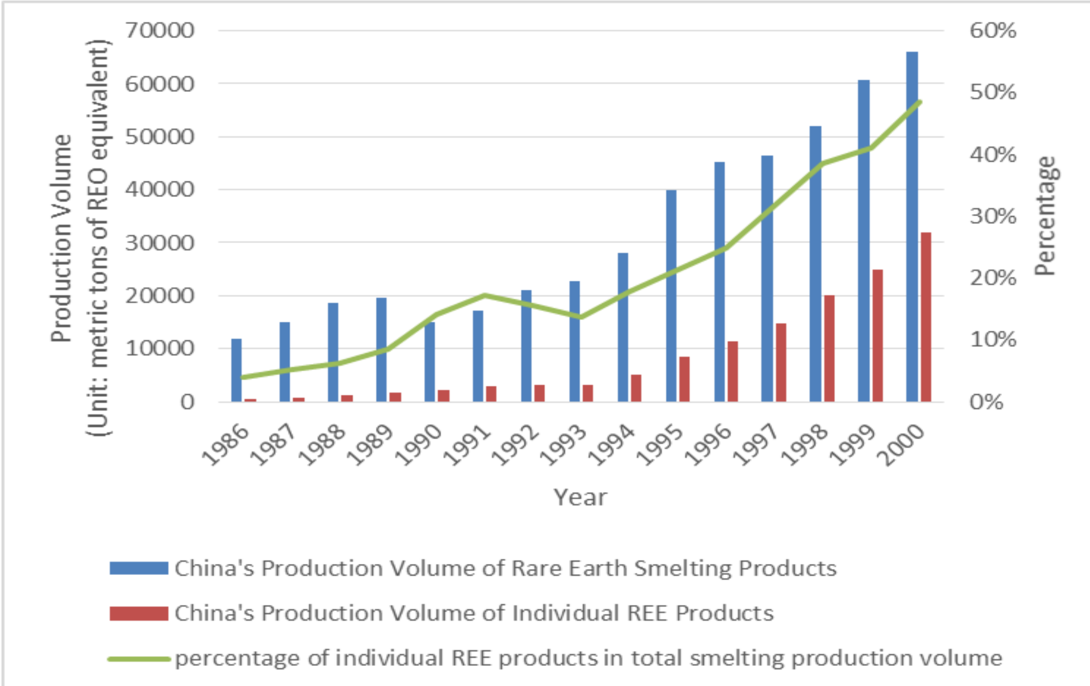

Figure 29 China's Production Volume of Individual REE Products in Comparison with Total Production Volume of Rare Earth Smelting Products (1986-2000)[223]

[223] Statistics are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评). After 2000, the *Annual Reviews of Chinese Rare Earth Industry* stopped reporting the production volume of individual REE products. Thus this graph only presents data until 2000.

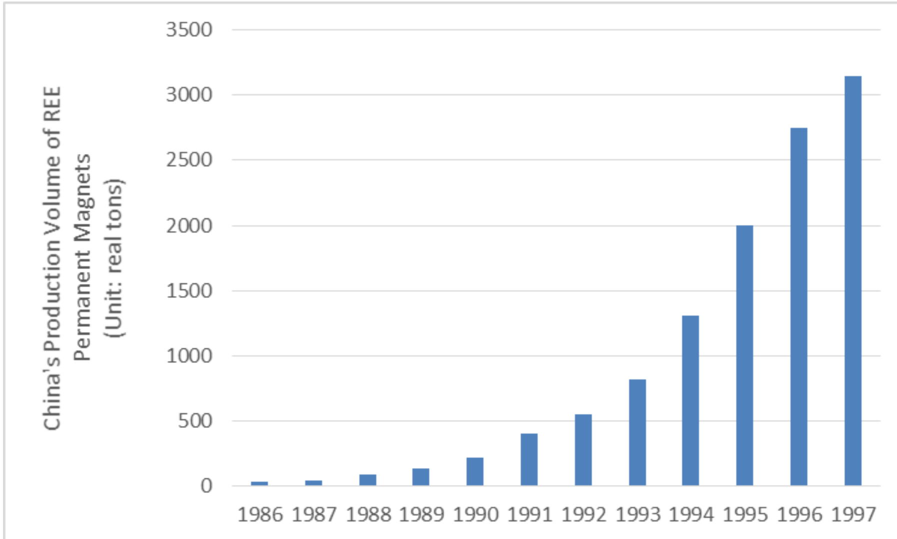

Figure 30 China's Production Volume of REE Permanent Magnets (1986-1997)[224]

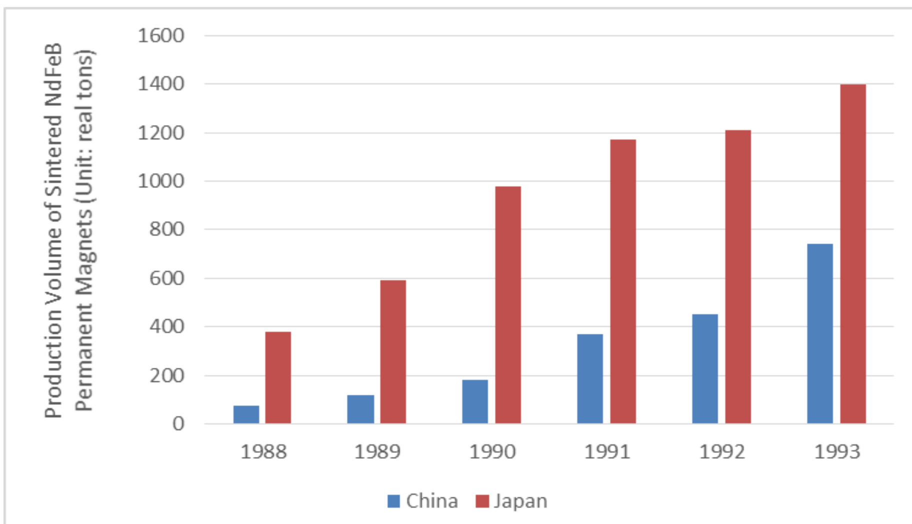

Figure 31 Production Volume of Sintered NdFeB magnets in China and Japan (1988-1993)[225]

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[224] Statistics are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评). Before 1996, the *Annual Reviews of Chinese Rare Earth Industry* reported production volume of rare earth permanent magnets (including Samarium Cobalt permanent magnets) in both real tons unit and metric ton in REO equivalent unit. After 1996, the *Annual Reviews of Chinese Rare Earth Industry* calculates production volume of rare earth permanent magnets only in unit of real tons. Thus for easier comparison across time, this graph presents data in unit of real tons instead of tons in REO equivalent.

6.5.1.4 Domestic Consumption Trailing behind Export

Although domestic consumption of rare earth products were growing rapidly, the majority of China's rare earth smelting products were produced for export in this period. As Figure 32 shows, from 1984 to 1997 export of rare earth products exceeded domestic consumption of rare earth products every year. By 1997, the volume of rare earth product export and stockpiling (31430 tons in REO equivalent) was about twice the volume of domestic consumption (15070 tons in REO equivalent), meaning that over 67% of China's rare earth products were produced for export.

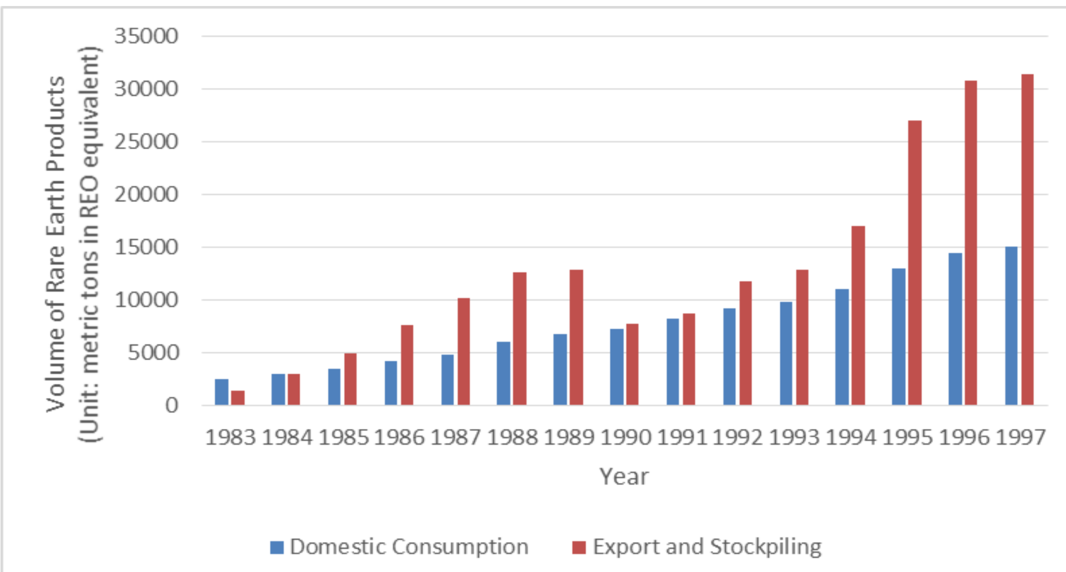

Figure 32 China's Consumption vs. Export/Stockpiling Volume of Rare Earth Products (1983-1997)[226]

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225 Data source: (Zhong, 1994). Zhong Junhui was a researcher at the GRINM.

226 Statistics are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评) from 1986 to 1997. The figures for year 1983 to 1986 were reported in the 1986 annual review. After 1997, the *Annual Reviews of Chinese Rare Earth Industry*

6.5.2 International Trade

6.5.2.1 Export Volume and Export Value

Along with production, China's export of rare earth products grew significantly in this period. Figure 33 and Figure 34 show China's export of rare earth products in volume and in value (earned foreign currency). Prior to the economic reform, China only exported 184 tons (in REO equivalent unit) of rare earth products from 1973 to 1978, earning 0.29 million USD in foreign currency. (Zhou, 1985) In the ten years from 1978 to 1988, China's rare earth export volume grew at an average annual rate of 50%, with a total increase of 54 times from 1978 level; export revenue in terms of acquired foreign currency in US dollars grew at an average annual rate of 67%, with a total increase of 170 times from 1978 level. (Ye, 1989) In 1988 China's rare earth export was 8320 tons, already accounting for 35% of global rare earth trade volume. (Ye, 1989) The major destination countries of China's rare earth export were advanced western economies, including Japan, the U.S. and France.

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stopped reporting the amount of domestic consumption and the amount of total export in unit of metric tons of REO equivalent, instead using real tons. Because the units are not standardized after 1997, one cannot just directly compare the pre-1997 and post-1997 figures, or directly compare the two statistics of consumption and export after 1997.

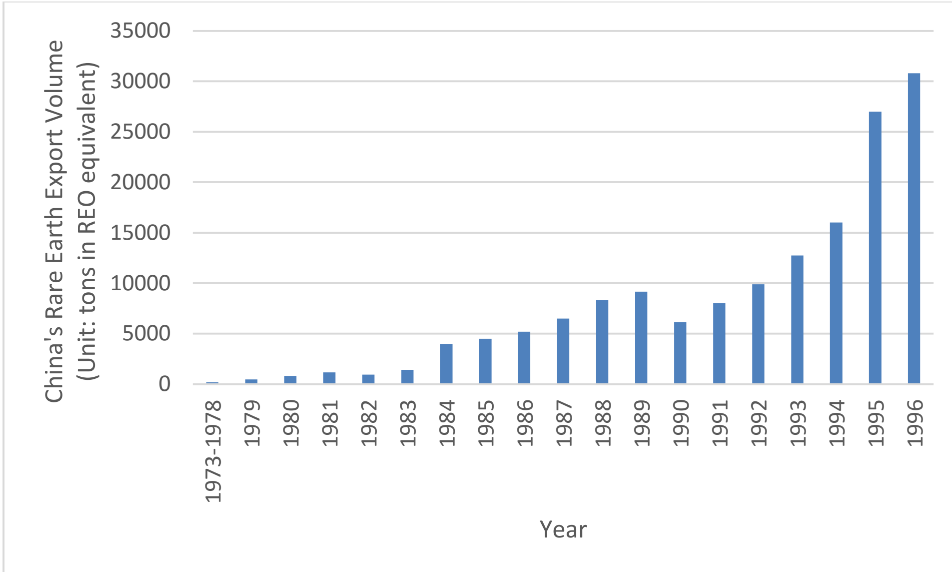

Figure 33 China's Rare Earth Product Export Volume (1979-1997)[227]

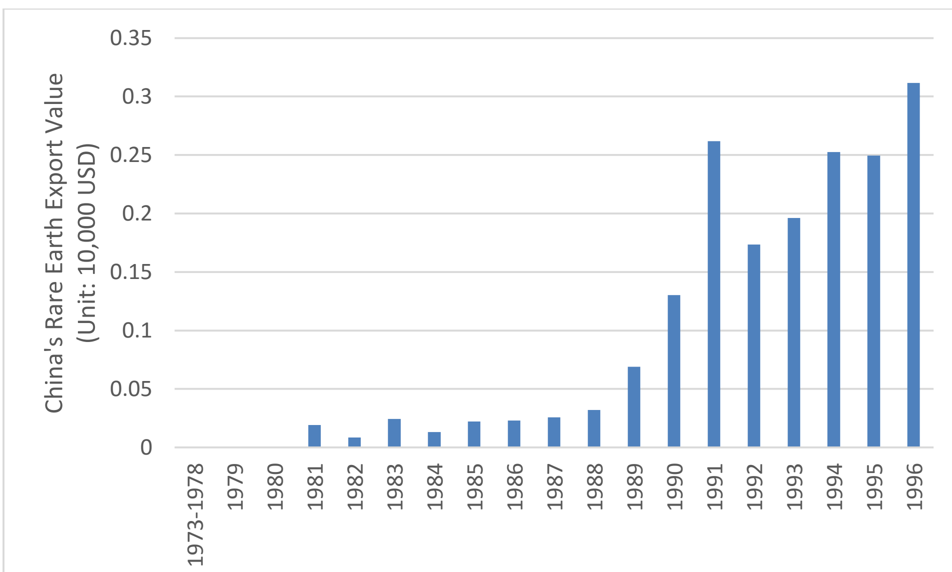

Figure 34 China's Rare Earth Product Export Value (1979-1997)[228]

[227] Export volume data are extracted from the *China Society of Rare Earths Yearbook 2007* (中国稀土学会年鉴 2007) and the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评). The export volume data included export volume of rare earth permanent magnets, rare earth mischmetal, fluorescent lights and other advanced products.

[228] Export value data are extracted from the *China Society of Rare Earths Yearbook 2007* (中国稀土学会年鉴 2007) and the *Annual Reviews of Chinese Rare Earth Industry* (中

The significant drop in export in 1990-1992 was due to several reasons. Firstly, China's export market took a brief hit in the second half of 1989 due to economic sanctions imposed by western countries after the June 4th incident. The export market was again depressed by the selling of the Soviet rare earth stockpiles after the collapse of the Soviet Union in December 1991. Secondly, there was already huge existing stockpiles of non-separated rare earth primary products by 1989, due to massively increased local production capacity in China in the 1980s. This made companies more desperate to sell off existing stockpiles at low prices, leading to price wars between producers and export revenue loss. (PRC State Council Rare Earth Leadership Group, 1989) Thirdly, 1989 was the first year that the three state-owned trading groups eligible for rare earth export coordinate export pricing and export volume control. Due to lack of knowledge of the foreign markets and lack of experience dealing with foreign traders, the three state-owned trading groups priced the separated rare earth products (more valuable than non-separated products) at below-market low prices (about 1/3-1/2 of the global market price for these products in 1988) (see Figure 35). This led to huge revenue loss on the export of separated rare earth products as well. The end result was not only a huge blow to China's export, but also a significant financial blow to major rare earth producers in other countries as well. Molycorp, the major U.S. producer was close to bankruptcy and up for sale in 1992. (Falconnet, 1992)

国稀土年评). The export value data included export value of rare earth permanent magnets, rare earth mischmetal, fluorescent lights and other advanced products.

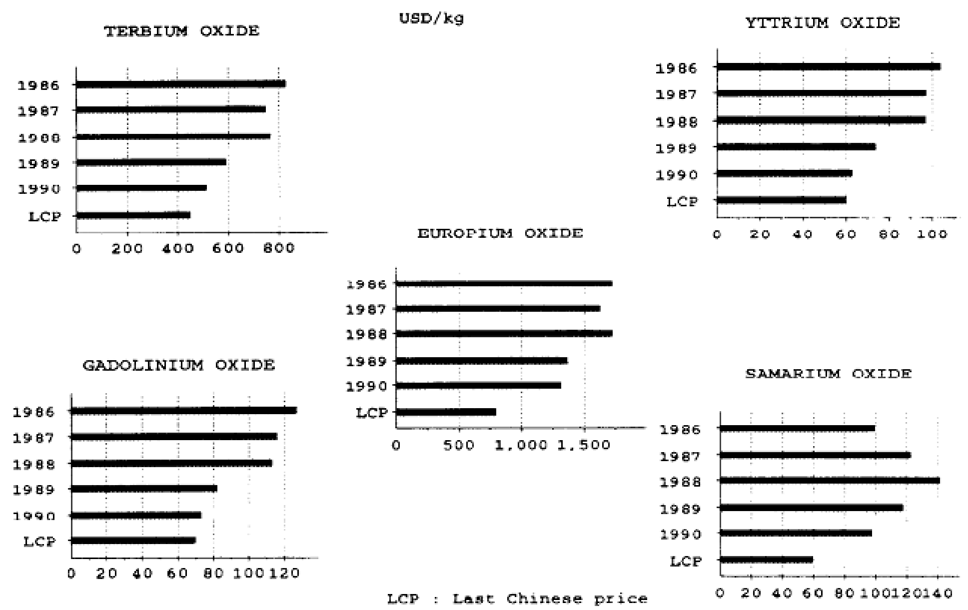

Figure 35 Rare Earth Product Export Price (1986-1991)[229]

China's export market turned better in the mid-1990s for several reasons. Firstly, the global demand for rare earth products grew substantially due to demand increase for REE-enabled permanent magnets and industry catalysts. Secondly, in terms of global supply, the Soviet stockpiles were close to be sold out on the global market. (Ma, 1995) Thirdly, the successive export control and production control measures enacted by the central government in the late 1980s and early 1990s helped correct the market price slump of the previous few years. (Rare Earth Office of the State Planning Commission, 1994) Finally, the French company Rhone-Poulenc, a major global rare earth processor in terms of production revenue, made the switch of sourcing from Australia to sourcing from China for its rare earth raw materials in 1992 and by 1996 Rhone-Poulenc was importing rare earth products worth about 20 million USD annually from China. (Liu,

[229] This graph was extracted from page 81 of the Rare Earth Industry Update written by Pierre Falconnet of the French major rare earth processor Rhone-Poulenc. (Falconnet, 1992)

1992; Rhone-Poulenc, 1996) Thus by 1997 China's annual export volume had grown to about 31,000 tons, with export revenue of 320 million USD. This was an increase of over 100 times in export revenue, achieved in less than two decades from 1979.

China's trade growth led to its increasingly important position in global rare earth product trade. Take the import market of Japan as an example. Japan has always relied on import for rare earth supply as it does not have any domestic rare earth deposit. China's export of rare earth products (including both ore concentrates and processed products) to Japan grew significantly in the early 1980s (see Figure 36). Mitsui Group, one of the largest corporate groups in Japan with about 25% share in Japan's rare earth consumption, signed a long-term deal in 1984 with China Non-ferrous Metals Import & Export Company and Jiangxi Metal Import & Export Company to import annually at least 200 tons of refined ores from South China's ion-adsorption clay deposits from 1985 to 1989. The rare earth concentrates would be processed in Mitsui's factories in Japan to provide raw materials for electronics and materials industries in Japan. (Shi, 1985) In 1985 (the year when China started export rebate policy) China surpassed France to become Japan's largest source of rare earth imports by value. (Liu, 1987) In the 1990s, Japan's rare earth production gradually shifted from processing of rare earth concentrates to production of value-added products such as abrasives, permanent magnets and hydrogen storage materials (NiMH batteries for instance), requiring the import of high-grade rare earth metals or metal alloys. (Roskill, 1997) China continued to be the major supplier as its own production of rare earth metals and separated rare earth products developed rapidly. As Figure 37 shows, in 1994 rare earth product imports from China accounted for 52% of Japan's total import in value, the first time that import from China surpassed import from all the other countries. In 1997 rare earth product imports from China rose to account for 67% of Japan's total import in value, and the ratio remained stable around 70% by 2002. It should be noted though that Japan's reliance on China's rare earth mine production across the production chain was larger than these figures would suggest, as Japan's major non-China supplier, the primary French producer Rhone Poulenc sourced most of its raw materials from China as well.

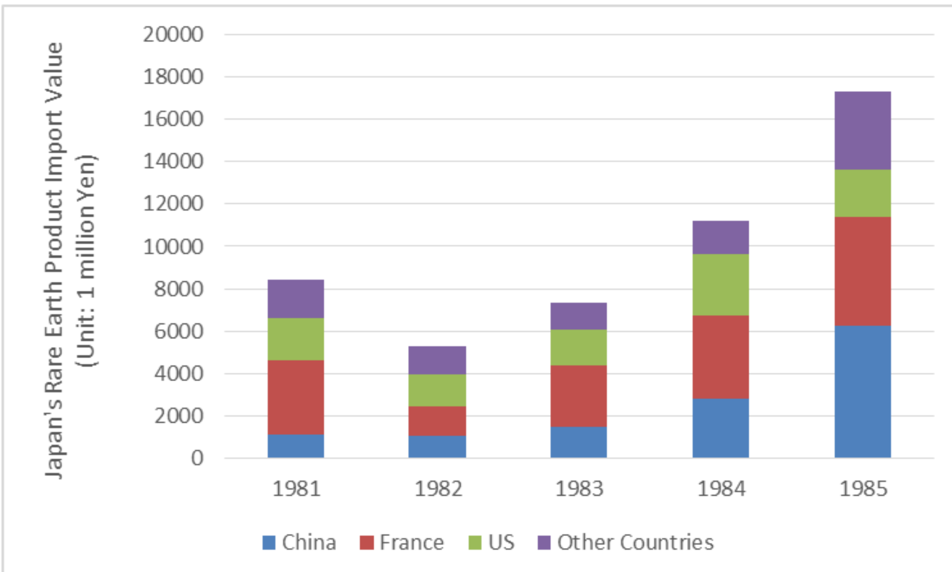

Figure 36 Japan's Rare Earth Import Value by Import Country (1981-1985) [230]

[230] Source: Liu (1987), originally data provided by Japan Metal (http://www.japanmetal.com/).

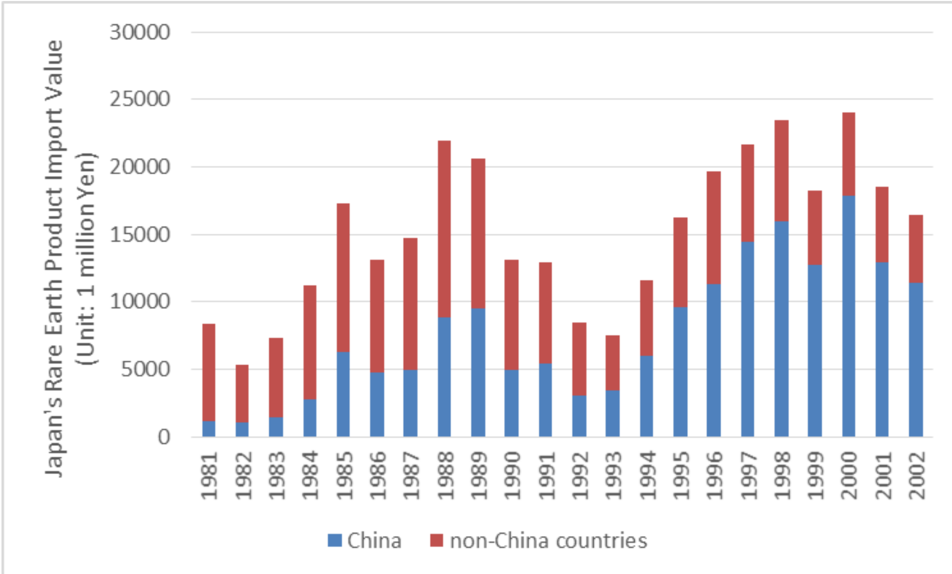

Figure 37 Japan's Rare Earth Product Import Value from China and non-China countries (1984-2002)[231]

6.5.2.2 Export of Higher-value Products

Although the majority of China's rare earth export were still low-value primary products (ore concentrates, unseparated rare earth products) in this period, the export of separated rare earth products (individual rare earth metals, individual rare earth oxides) and advanced products (permanent magnets etc.) was rapidly growing relative to the total export. **Figure 38** and **Figure 39** show China's export of higher-value rare earth products (including both separated REE products and advanced products) in volume and in value (earned foreign currency) in comparison with the total export from 1981 until 1998. As

[231] Import statistics from 1980 to 1984 was extracted from Liu (1987). Import statistics from 1984 to 1994 was extracted from Takaki (1995, p.37). Takaki Junki was the Chairman of the Japan Society of Newer Metals, an affiliate organization of the Ministry of International Trade and Industry of Japan. Import statistics after 1994 was extracted from Aoyama (2003, p. 24). Aoyama Ichizuo was the Head of the Nonferrous Metals Division in the Bureau of Manufacturing Industries in the Ministry of International Trade and Industry of Japan.

can be seen from both figures, export of higher-value rare earth products grew substantially, at an average annual rate of 66% in volume and 60% in value. In terms of the ratio in total export, in 1991 China's export value of higher-value products grew to account for more than half of the total export value for the first time. The rapid expansion in the export of primary products (for instance rare earth chlorides) in 1992-1994 due to major western companies shifting raw materials sources to China drove down the ratio of higher-value product export in total export. (Rare Earth Office of the State Planning Commission, 1993; Rare Earth Office of the State Planning Commission, 1994) Yet by 1997, China's annual export of higher-value products had climbed back to account for 40% of total export in volume and 72% of total export in value.

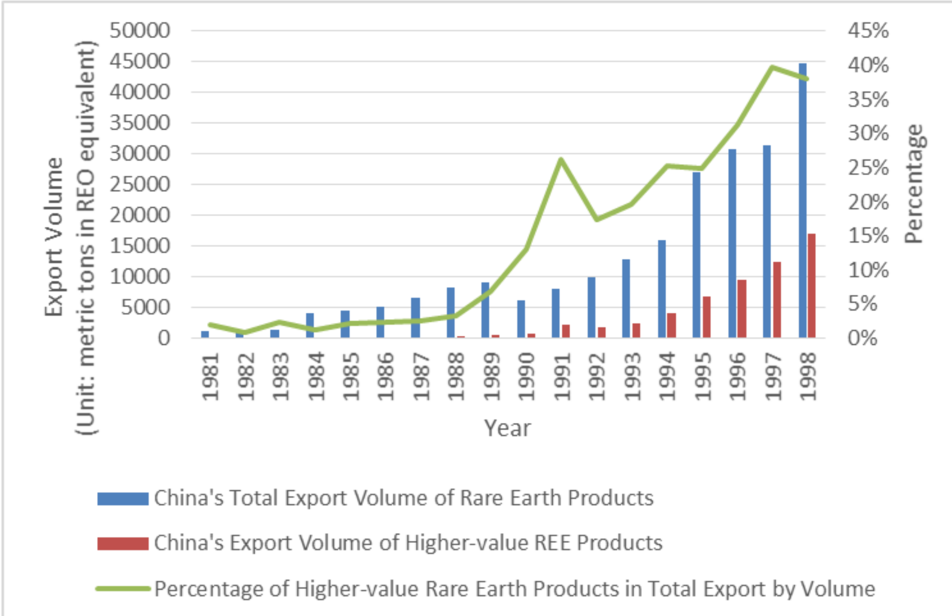

Figure 38 China's Export Volume of Higher-value Rare Earth Products in Comparison with Total Export Volume (1981-1998)[232]

[232] Export volume data are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评). After 1998, the *Annual Reviews of Chinese Rare Earth Industry* stopped separate reporting on the export of individual REE products, instead focusing on separate reporting on the export of permanent magnets and other different kinds of advanced products. Thus to allow for accurate comparison, this graph only presents data until 1998.

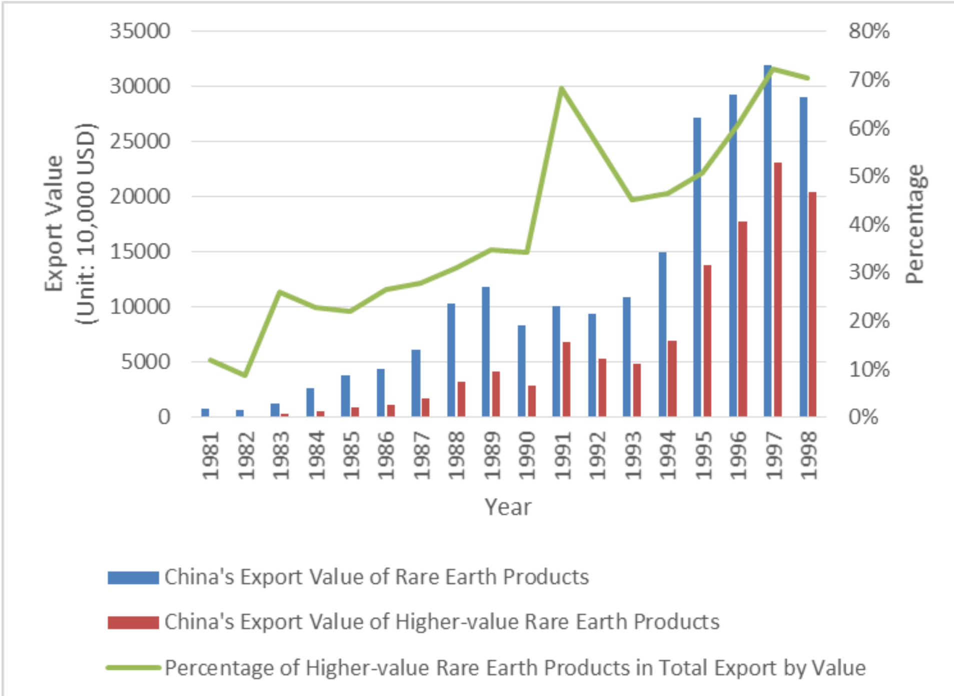

Figure 39 China's Export Value of Higher-value Rare Earth Products in Comparison with Total Export Value (1981-1998)[233]

6.5.3 Market Structure

The market structure in the Chinese rare earth industry in this period was highly competitive. The institutional factors discussed in the previous subsection resulted in the localization of industry production as well as the low barrier to market entry, creating a large and rapidly growing number of local market actors. By 1985 within China there were 21 rare earth mining and ore sorting companies, 16 companies producing rare earth primary products and 15 companies producing rare earth alloys. In terms of rare earth applications, by 1985 there were 30 companies producing REE-enabled metal products,

[233] Export volume data are extracted from the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评). For reason the same as above, this graph only presents data until 1998.

113 companies producing REE-enabled steel products, 12 companies producing REE-enabled magnets, 11 companies producing REE-enabled electronic and lighting products, 7 companies producing REE-enabled petrochemical products, 30 companies producing REE-enabled glass and ceramic products, 34 companies producing REE-enabled textile products and 2 farms using REEs in fertilizers[234]. In the 7th Five-Year period (1986-1990), along with rapid increases in production and export, the competition in the market increased substantially. By the late 1980s the industry had grown to a point where there were more than two thousand small and median-scale production units competing against each other, producing overlapping ore and primary products using similar technologies. (PRC State Council Rare Earth Leadership Group, 1988; PRC State Council Rare Earth Leadership Group, 1989) This excessive production capacity resulted in the oversupply of rare earth products, price wars among producers and worsening profit margins across the industry during the period of weak market demand in 1989-1992. Combined with the restrictive industrial policies on production and export enacted by the central government, the depressed market further prompted the closure of a large number of local companies. (Ma, 1995) Yet following the recovery and strong growth of market demand, by 1996 the number of Chinese producers had again increased substantially, and the problems of over production, severe price competition and worsening profit margins re-emerged. (Roskill, 1997)

The market competition was particularly acute in the Gannan-Yuebei region in South China, where HREEs were produced using rudimentary techniques and sold

[234] The numbers are all calculated from the companies listed in the *Overview of Chinese Rare Earth Industry* (中国稀土工业便览), edited by Zeng Xinglan et al. and published by the National Rare Earth Applications Promotion Leadership Group Office.

primarily for export. In Jiangxi Province alone, there were more than a thousand mining sites in operation in 1988, including more than 200 mining sites in Xunwu County and more than 400 mining sites in Xinfeng County, two major counties producing and exporting ion-adsorption ores. (Ma, 1995) Along with the proliferation of mining sites was the proliferation of local smelting projects. By 1989 there were more than 30 rare earth smelting companies in Jiangxi Province and Guangdong Province. (Ma, 1995) Although the weak market in 1989-1992 prompted the closure of a large number of local mining sites and rare earth companies, by the mid-1990s there was again a proliferation of local production units. A survey conducted in Pingyuan County in Guangdong Province in 1995 concluded there were more than 200 private illegal mining sites in this county alone. (Xu et al, 1999) In contrast, rare earth mining in Inner Mongolia in North China was conducted by the single company, Baotou Steel Rare Earths in Baiyun-ebo, making it a quasi-monopolistic supplier for rare earth smelting and application companies in the local market. As a result, LREE production from North China was "in chronic under-supply" and the majority of its production was consumed by domestic producers instead of export. (PRC State Council Rare Earth Leadership Group, 1989)

6.5.4 Environmental and Social Impact

The overriding emphasis on industry output and export in this period meant that environmental protection had low priority on the government and corporate agendas. In general, projects often could get by with minimal environmental treatment measures. In Baotou for instance, the lack of local regulation allowed local companies to build small-size factories directly on the upstream of local rivers, near local resident communities and even in farming districts. New projects could start production even before approval was granted from the local environmental protection bureaus, and appeals from local residents to close polluting plants were often ignored. (Ma et al, 2001) As a result, while the rare earth industry enjoyed strong growth in production and export, it had long-term detrimental effect on the local environment, the health of the local community and in some cases incurred social problems for the local government.

6.5.4.1 Environmental and Social Impact in North China

In North China, the primary environmental consequence of rare earth industry was waste water, waste gas and radioactive waste from the mining and processing of Baiyun-ebo ores which contained radioactive Thorium and Fluoride. In terms of waste water and radioactive waste residues, Baotou Steel Rare Earths, the primary mining company, began dumping the waste from processing of ores into an open area close to its smelting plants in the 1950s, and over time a “tailings dam” (尾矿坝) was formed to store the waste. By 1998 the tailings dam had grown to encompass an area of 11 square kilometers in size, and the dam was receiving about 800 tons of waste containing radioactive elements annually. (Bai et al, 1999) Its direct exposure to the local environment without any treatment resulted in high radioactive exposure, polluted ground soil, as well as polluted water seeping down to aquifers and contaminating groundwater as far as 2 kilometers downstream. Such grave environmental consequences proved to be detrimental for the local community: a study conducted by the Bureau of Radioactive Environment Management of the Baotou City government on the deaths of local residents in Baiyun-ebo District between 1995 and 1997 concluded that cancer was the No. 1 cause of death for local citizens, and the death rate from cancer (188.62/100,000) was double the national average (94.36/100,000). (Zhang et al, 2000) Environmental treatment was barely existent for rare earth smelting and applications production as well. By 1998 only two rare earth companies in Baotou had waste water treatment facilities, namely the 202 Factory controlled by the Ministry of Nuclear Industry/ China National Nuclear Corporation, and the Baotou Luxi-Rhone RE Company, a joint venture of Rhone Poulenc. All the other local rare earth companies directly dumped on average about six hundred thousand tons of waste water into the local rivers flowing into the larger Yellow River[235] annually. The polluted local rivers contained 4800% higher than the compliance level of ammonia and nitrogen, 630% higher for fluoride, and 1060% higher for radioactivity. As a result, the portion of the Yellow River in this area was unsafe even for utilization by local power plants, let alone for drinking. (Bai et al, 1999) In terms of waste gas, by 1998 49% of the local companies producing rare earth chlorides (a major rare earth primary product), primarily small-sized companies, had no treatment facilities to treat the roughly 3800 tons of chlorine gas discharged into the air annually. (Bai et al, 1999) Local companies producing other rare earth products directly discharged in total waste gas containing roughly 464 tons of fluoride, 2223 tons of sulfur oxide, 1364 tons of sulfuric acid vapor and 407 tons of dust into the air in 1997. (Bai et al, 1999) Such pollution posed detrimental long-term environmental and health hazards to the local community. It also strained the relations of the local government and companies with the local minority group (Mongol), who primarily depended on farming for living and were thus highly affected by the pollution. Local Mongol farmers repeatedly petitioned to the higher authority to close the polluting companies, and when the requests were not fulfilled, they

[235] The Yellow River is the major river in North China passing through nine provinces and autonomous regions, including the Inner Mongolia Autonomous Region. It is the primary source of drinking and industrial use water in North China.

further clashed with the local government through refusing to pay taxes. (Bai et al, 1999; Cai et al, 2002)

6.5.4.2 Environmental and Social Impact in South China

In the Gannan-Yuebei region in South China, the major environmental consequences of mining and processing ion-adsorption rare earth ores were the loss of ground layer of vegetation, soil erosion and degradation. (Xu et al, 1999) Until the late 1990s the ores were mined primarily by open-pit tank leaching (露采-池浸). Tank leaching is a hydrometallurgical method of extraction that could cause direct damage to the ground layer of vegetation and significant amount of waste residue difficult to treat (see Figure 40 for the procedures). As a result, after the mineral extraction the entire mountains were "stripped" the surface with only bare rocks and waste left. (Yuan, 2009) A survey conducted by the Ganzhou Nonferrous Metallurgy Research Institute found that extraction of REEs by tank leaching in the Gannan region led to the loss of 1.6 square kilometers of vegetation, the desertification of 2.13 square kilometers of land, as well as the dumping of 160 million tons of waste on open ground (usually arable farm land) annually. (Du, 2002) The waste discharge containing oxalic acid, when not treated properly, could pollute the local water and result in additional health hazards for the local community. The consequences for the local ecological environment were detrimental and irreversible. For instance, *Southern Weekly* reported that the Zoutao Village in Xingning Prefecture in Guangdong Province had a history of rare earth mining from 1984; because of the decade of waste dumping and pollution of oxalic acid to the local water system, local farmers had to abandon farm lands and fish ponds and leave the village to find work; those unable to work outside the village had to get water from nearby mountain areas. As a result, residents petitioned that the local government officials should pay for relocation expenses; yet local governments could not fulfill their requests due to budget constraints. (Southern Weekly, 2005)

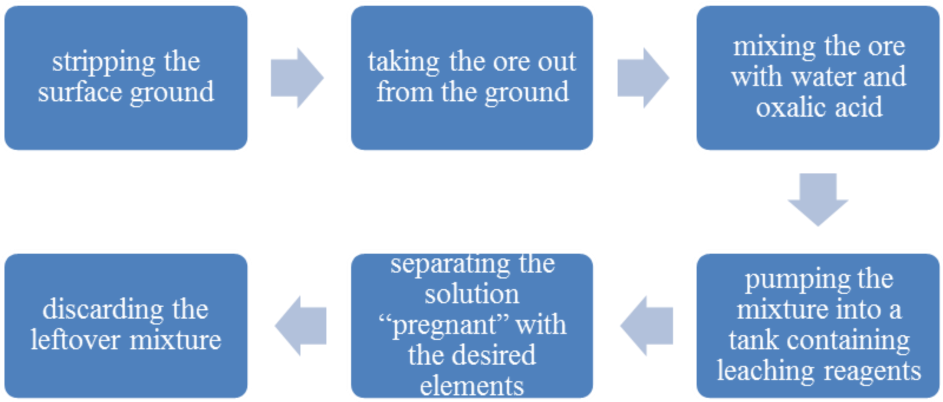

Figure 40 Tank Leaching Method to Extract REEs from Ionic Adsorption Clay Deposits

6.6 Conclusion

As this chapter shows, the Chinese state governance over the rare earth industry from 1978 to 1997 was driven by the goals of developing export for economic and strategic benefits, as well as achieving global dominance in production and trade through transitioning towards and regulating a market economy in the sector. Though the state role in this period featured the relaxation of the previous planned economy towards the market, the state only recalibrated but never relinquished its active control over the industry. The state introduced industry-specific policies, regulations, initiatives and enterprises to promote as well as regulate the process of marketization and industry development. The measures included export promotion and tax rebate, production promotion and regulation through high-level state plans, restrictions on foreign investment in mining and smelting, production and export control on specific primary products, and support for basic research and high-tech development zones. At the same time, there were larger political institutions and institutional changes, including overlapping bureaucratic control among central and local authorities over central SOEs, devolution of authority on local economic affairs, "one-level downward" local cadre management system with emphasis on economic output, and unique IPR institutions promoting technology transfer. Though not specific to the rare earth industry, these institutional changes had considerable influence on shifting central-local dynamics in the authority over industry and substantially lowering the barrier to market entry. This resulted in the explosive expansion of industry production capacity and the expansion of the non-state sector (cooperatives and private enterprises) in mining and smelting. It also led to diluted enforcement of the central government policies and regulations at local levels.

The combined effect on the industry, as can be seen from the last section on development outcomes, was two decades of spectacular market growth as production and export soared in both volume and in value (earned foreign currency). By 1997 China's rare earth industry was close to global dominance in rare earth production and export, having successfully convinced major western consumer companies to source materials from China for the long term. Although the industry primarily produced low-value products, its production and trade of higher-value products grew rapidly and was about to take the lead in total production and export by the late 1990s. Thus what the early reform leaders envisioned as China becoming "first rank in production, first rank in export" was largely achieved. While the state consistently crafted policy changes in this period to achieve its reregulation goals, the results were not highly satisfactory; several important issues of concern emerged. The production and export of advanced products and applications, which would bring higher value returns for the extraction of minerals belonging to the state, remained still quite small. The market structure was highly decentralized despite of the central government attempts to curb local production, leading to over supply compared to market demand and poor industry profit margins, particularly in South China. Poor environmental record and its detrimental impact on the local communities were also widely present, casting dark clouds on the industry's long-term sustainability of development.

CHAPTER 7 STATE REREGULATION UNDER DEEPENING ECONOMIC REFORM (1998-2007)

This chapter studies the Chinese state reregulation over the rare earth industry and market from 1998 to 2007, a period when the industry enjoyed complete dominance in global production and trade. This chapter first outlines the macroeconomic environment for the industry development in this period. The Chinese state continued the marketization of the Chinese economy and greatly expanded China's integration with the world economy. The chapter then analyzes the state goals and narratives in guiding the rare earth industry development in this period. The state development narratives featured prominently regulation through market mechanisms in order to achieve long-term sustainable development and sustain global dominance in the post-WTO-accession era. The chapter then outlines industry-specific policies in this period. The central government implemented new policies and changed existing policies in order to control rare earth mining and export and centralize the market structure. The chapter then analyzes larger political institutional changes in state bureaucracy, which collectively resulted in the weakening of the central government's capacity to impose industrial policies in the local regions. The chapter concludes with analysis of the industry in production, trade, market structure and socio-environmental impact, as the outcomes of state reregulation.

7.1 Macro-level Economic Change: Expansion of Domestic Market Economy and International Trade

After the de facto reform leader Deng Xiaoping died in February 1997[236], the two successive central government administrations overseeing the national economy were the President Jiang Zemin/Premier Zhu Rongji administration (1998-2003) and President Hu Jingtao/Premier Wen Jiabao administration (2003-2013)[237]. The central government continued the marketization reform and greatly expanded China's participation in international trade. This section summarizes major macroeconomic reform policies which pertain to the rare earth industry from 1998 to 2007.

7.1.1 Marketization Reform of the State-owned Enterprises (SOEs)

Chinese state-owned enterprises underwent significant institutional reform under the State Council headed by Zhu Rongji in 1998-2003. After two decades of economic reform in China, the SOEs suffered from high non-performing loans, high inefficiency and chronic under-performance compared to the private sector. The 15th National Party Congress in 1997 stated that the SOE reform to be undertaken in the next three years would be the most important task facing the nation's economy. (Zhou & Xia, 2008)

The SOE reform followed the "Zhua Da Fang Xiao" ("Control the Big, Let Go of the Small") strategy decided at the 5th Plenum of the 14th National Congress of the CPC

[236] Deng remained the de facto paramount leader of China until his death, although he retired from official leadership position in the Communist Party in 1987. The state administration from 1987 to 1998 was headed by President Jiang Zemin and Premier Li Peng.

[237] The Chinese President presides over the PRC government and is the paramount political leader. The Chinese Premier heads the State Council, which serves as the administrator and regulator of day-to-day government functions. Though all Chinese laws need to be ratified by the National People's Congress (NPC), the Premier and the State Council has the most significant influence over the national economy, as the NPC largely functions as a rubber stamp for decisions made by the central authority. Here the time period of 5 years corresponds to each 5-year tenure of the State Council. After the first term of 2003-2008, the Hu Jingtao/Wen Jiabao administration ruled China for a second term from 2008 to 2013.

in 1995. The government ordered the large SOEs to undertake shareholding reform (股份制改革） to become modern shareholding companies. There were various kinds of restructuring (重组改制）, resulting in complicated ownership structures[238]. For the largest SOEs in strategic sectors (such as energy, telecommunications, transportation), the state became the largest shareholder, and the SOE's managers and employees were allowed to purchase shares. For relatively smaller SOEs, corporate managers and employees were allowed to purchase and own the majority of the share, making them effectively employee-owned co-op companies. Some selected SOEs were allowed by the state to become stock companies (上市公司） trading on domestic or international stock exchanges to attract additional capital from individual or institutional investors. (Central Committee of the Communist Party of China, 1999) This additional capital influx compensated for the declining loans available to the SOEs from state-owned banks, as the state-owned banks were also going through reforms to clear away old debts and were wary of lending new credits to the SOEs. (Lardy, 1998) Yet the state usually remained the largest shareholder of these stock companies, and limited amounts of shares were allowed to be traded openly on the exchange. For some large SOE conglomerates with high debts, more profitable assets were divested to become private spin-offs allowed to be listed on the stock market and to develop more rapidly with the access to additional capital, while the parent SOE (wholly or partially owned by the state) became a shareholder of these spin-offs and received dividends to help turn around the under-

[238] For an authoritative overview of central government policies in the SOE reform, see The Decision of the Central Committee of The Communist Party of China on Major Issues Concerning The Reform and Development of State-Owned Enterprises adopted at the 4th Plenum of the 15th CPC Central Committee on September 22, 1999 at http://cpc.people.com.cn/GB/64162/71380/71382/71386/4837883.html

performing assets. Local non-production units (such as schools, hospitals, daycare centers and dining companies) of the SOEs, which used to provide low-cost services as an extension of the state welfare to the SOE employees and were likely to incur debts rather than profits, were disintegrated from the mother company (主辅分离） and became private independent entities or transferred to become non-profit entities supervised by local governments. (PRC State Economic and Trade Commission, 2002a) In addition, a few selected under-performing large SOEs were allowed by the state to go through "debt-equity swap" (债转股): the Ministry of Finance instructed the four state-owned national banks to establish asset management companies; these asset management companies acquired bad bank loans given to the SOEs, and in return these companies became shareholder of the in-debt SOEs and could receive dividends or sell their share back to the SOEs once the SOEs became profitable. (PRC State Economic and Trade Commission, 2000a; PRC State Economic and Trade Commission et al, 2003) The "debt-equity swap" in effect cleared a large portion of the debt of these large SOEs, as the debt was temporarily shifted from the SOEs to the asset management companies at each bank underwritten by the Ministry of Finance. Thus although the number of large SOEs wholly owned by the state were drastically reduced through the shareholding reform, the state in the end still retained majority or partial control of most of the largest reformed SOEs, and in some other cases the state received dividends through owning equity of the more profitable non-state spin-offs of under-performing large SOEs. On the other contrary, medium and small-sized SOEs were much less likely to go through shareholding reform. They were more likely to be given up by the state to the private hands through auctioning, leasing, mergers, joint-operations, or were allowed to go bankrupt. (Si, 1998)

After 5 years of drastic reform under the Zhu Rongji administration, the post-2003 State Council headed by Wen Jiabao continued the corporate restructuring of the SOEs, yet with a new focus on the consolidation and expansion of the state-owned assets. In the 2003 State Council Reform[239], the State Economic and Trade Commission was abolished; replacing its leadership in the SOE reform was the new State-owned Assets Supervision and Administration Commission (SASAC). As a supervisory agency, SASAC not only directly supervises state-owned enterprises owned by the central government (then 161 in total number), but also directly manages state-owned capital (then about seven trillion RMB) as an investor on behalf of the state.[240]. SASAC has continued leading the corporate restructuring of the SOEs into shareholding companies and stock companies. In 2006, SASAC announced that one major goal of the SOE reform was "promoting the concentration of state-owned capital on major industries and key fields, enhancing the controlling power of state-owned economy, and bringing its leading role into play". (PRC SASAC, 2006) In particular, the SOEs in industries "concerning national security, major infrastructure and important mineral resources, industries that provide essential public goods and services, as well as the key enterprises in pillar industries and high-tech industries" were instructed by the SASAC to be consolidated to form supersized "alliance groups" (集团) that could compete in the global market. (PRC SASAC, 2006) In Xinhua New Agency's interview of Li Rongrong, then Director of

[239] Corresponding to the 5 year tenure of State Council leadership, there have been major changes to the agencies comprising the State Council every 5 years. Since China started its economic reform, the State Council has implemented major reforms in the years of 1982, 1988, 1993, 1998, 2003, 2008, 2013.

[240] For more information about the functions of SASAC, see its website at www.sasac.gov.cn. The local SASAC at provincial and prefectural levels of government are responsible for managing the SOEs and state-owned capital within their jurisdictions

SASAC in 2006, Li said that SASAC would consolidate the 161 large SOEs under its direct supervision into 80-100 large SOEs by 2010, among which 30-50 SOEs should be supersized alliance groups of large SOEs capable of competing in the global market. (Xinhua, 2006a) However, SASAC fell behind its own schedule: by 2008 the number of SOEs under the supervision of SASAC was still 150, far above its goal of 80-100 by 2010. (Liu, 2008)

7.1.2 Marketization of the S&T Institutions and Focus on Technology Innovation

Sharing Deng's vision of the S&T development as the driving force for China's economic development, the post-Deng administration prioritized the marketization of China's S&T research institutions and started establishing a National Innovation System (国家创新体系). In 1995, then President Jiang Zemin identified the national strategy of "Invigorating China through Science and Education" (科教兴国). In the 1998 State Council Reform, the State Science and Technology Commission (SSTC) was renamed as the Ministry of Science and Technology (MOST). As the new supreme agency for S&T administration and policy, MOST oversaw continued marketization of China's S&T system. In August 1999 the State Council released *Decision on Increasing Technology Innovation, Developing High-tech Industries and Achieving Commercialization*. This landmark policy document stressed that technology innovation would drive economic development in China, and that the enterprises rather than the government would be the vehicle of high-tech innovation. (PRC State Council, 1999a) Starting in 1999 the science and technology research institutes under the supervision of central government agencies went through major marketization reform. The research organizations and groups involved in applied research were gradually privatized into independent shareholding companies, or became subsidiaries of the major SOEs in the corresponding industries. (PRC State Council, 2000a) The basic research institutes or research groups remained non-profits primarily funded by the central government, but were also encouraged to provide paid services to the private sector through contracts. (PRC State Council, 2000a) The National Technological Innovation Project (技术创新工程), a major policy initiative starting in 1996, was implemented to strengthen the innovation capability of large and medium-scale Chinese companies. The National Technology Innovation Project was started by the State Science and Technology Commission and the State Economic and Trade Commission in 1996, with six firms picked as national technological innovation pilot firms. (PRC State Science and Technology Commission, 1997) The firms chosen to participate in the project were encouraged to set up in-firm technology innovation centers, to develop the R&D, technology management and technology marketing workforce, and to collaborate with research institutes and universities to create and commercialize internationally competitive proprietary technologies. (PRC Ministry of Science and Technology, 1998; PRC State Economic and Trade Commission, 2000b) By 2003 national-level innovation firm centers had grown to 302, and local innovation firm centers had grown to over 2000. (Wang, 2003)

The following Hu Jingtao/Wen Jiabao administration prioritized “indigenous innovation” (自主创新) as the central task for China’s S&T institutions. Specifically, in a speech at the Inaugural Chinese Science and Technology National Congress, President Hu identified China’s S&T development goal as “Innovation-oriented Country” (创新型国家), focusing on “key areas promoting economic development and promoting future development”. (Hu, 2006) The administration sought to expand the National Innovation

System into five sub-systems: a firm-centric technology innovation system linking production, research and development; a knowledge innovation system encompassing both S&T research and higher education teaching; a national defense technology innovation system linking defense S&T with civilian S&T; a regional innovation system promoting local innovation and economic development; a socialized network of science and technology mediator services. (PRC Ministry of Science and Technology, 2006) Policies shifted from the direct provision of funding to the creation of service networks and cluster incentives such as development zones for firms to development R&D capabilities. (Forster, 2006) The State Council subsequently released another landmark S&T policy document, the *Medium and Long-term Plan for China's Science and Technology Development (2006-2020)* (abbreviated as MLP). (PRC Ministry of Science and Technology, 2006) The MLP made the goal that by 2020 China's dependence on foreign technology would reduce to under 30%, and China would advance to the top 5 globally in the annual number of new patents granted and the number of citations in international science and technology journals. The MLP identified 62 "important areas of research" (重点领域) to receive state support, including "sustainable and efficient use of mineral resources" (矿产资源高效开发利用) as well as "comprehensive treatment of pollution and recycling and reuse of waste" (综合治污与废弃物循环利用). In addition, the Ministry of Finance created a platform of policies in 2006-2007 to encourage domestic technology innovation, by granting domestic products bearing the recognition of "indigenous innovation" the priority in government procurement. (PRC Ministry of Finance, 2006a) Similarly, in order to sponsor local high-tech industry development, many provincial and prefectural-level governments exclusively procured from companies bearing the recognition of "indigenous innovation" within their own jurisdictions. (Bai & Xu, 2012) The rules gave Chinese technology companies, particularly those in clean energy and information technology, significant advantage in securing government contracts. Due to international pressure alleging that the policy discriminated against the U.S. and European manufacturers, the exclusive government procurement of domestic ingenious innovation products was later halted in 2011. (PRC Ministry of Finance, 2011)

7.1.3 WTO Entry and International Economic Expansion

China's economic growth and integration into the global economy was greatly enhanced in this period after China's accession to the World Trade Organization (WTO) in 2001. The previous two decades of reform and opening policy campaigns had led to significant and consistent high growth in export (see Figure 41). Even in the midst of the Asian Financial Crisis which devastated many Asian economies in 1997-1999, China did not devalue its currency and the Chinese economy grew at about 8% yearly rate. (See Figure 42) The membership in the WTO since 2001 has allowed China to attain rapid export-led economic growth and to emerge as a major global trading hub. Between 2001 and 2007 (before the 2008 Global Financial Crisis), China's export grew at an impressive average rate of 21.9%, and its GDP growth continued a growth streak averaging 10.8% per year. (See Figure 41 and Figure 42) The consistent high GDP growth was still primarily driven by investments and export growth instead of domestic consumption: exports of goods and services accounted for about 30% of China's GDP (see Figure 43). The membership in the WTO has also allowed China to ramp up its import of raw materials needed to support its rapidly expanding manufacturing and service sectors. In less than a decade China moved from being the world's fourth-largest trading nation to the second in both exports and imports. China also became the largest destination of exports from the Less-developed Countries (LDCs) and the largest developing country in terms of outward FDI. (Permanent Mission of China to the WTO, 2011)

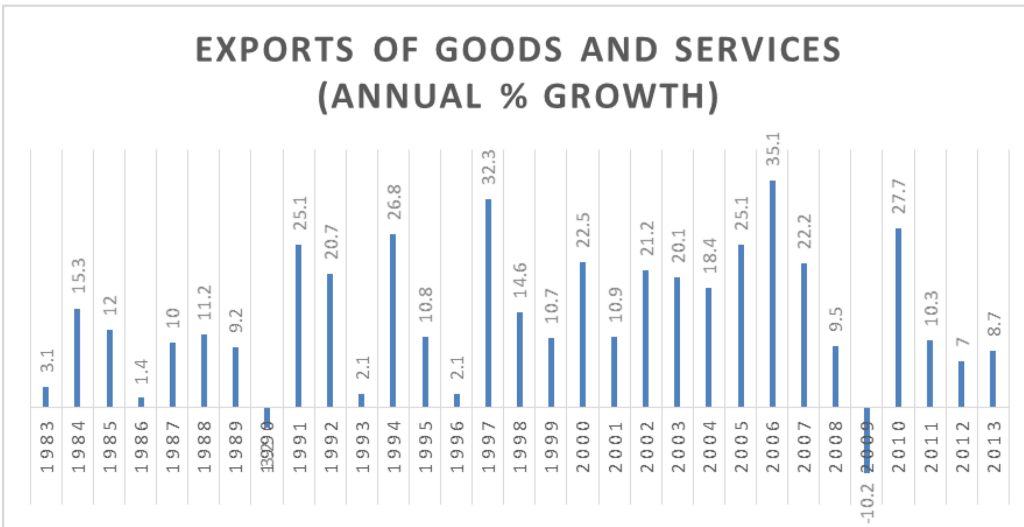

Figure 41 China's Annual Growth Rate in Exports of Goods and Services (1981-2014)[241]

[241] Data source: World Bank.

Figure 42 China's Annual GDP Growth Rate (1981-2014)[242]

Figure 43 China's Export as Percentage of GDP (1981-2014)[243]

7.2 Goals and Narratives of the State

Narrowing down the focus from the national economic reform to the rare earth industry, this section studies the Chinese state's goals and narratives in industry

[242] Data source: World Bank.
[243] Data source: World Bank.

reregulation in the period of 1998-2007. As China became the de facto global rare earth producer and major exporter of rare earth products, the state's goals for reregulating the industry shifted away from primarily expanding industry production and market growth towards creating higher value and sustainable return from the extraction and utilization of the strategic resource. In particular, two goals were evident: promoting sustainable development through curbing production capacity and environmental pollution; and promoting industry upgrading through fostering indigenous innovation and value-added production. The central government development strategies continued to feature both marketization (promoting industry growth and market expansion) and regulation (keeping the industry development under state control).

7.2.1 Goals of State Reregulation: Sustainable Development

In contrast with the emphasis on fast export growth and production expansion in the previous two decades, sustainable development became an important goal of the state reregulation in this period. As China attained global predominance in rare earth production and export after fast growth for two decades, the central administrations realized that it would only be a matter of time before China would run out of this non-renewable resource. Thus the state's emphasis on sustainable development had several reasons: economically, the state wanted to maintain production control and ensure long-term market competitiveness; environmentally, the state wanted to curb the already rampant pollution and resource waste, and decrease resultant environmental casualties and social unrests; from a more long-term perspective, the state wished to preserve China's advantages in the endowment as well as the utilization of the rare earth resources as raw materials for important civilian and defense applications for future generations.

The state goal of fostering sustainable development was aptly illustrated by a speech given by Liu Tie'nan[244] at the 2002 National Conference of Rare Earth Office Directors[245]. Liu was then the Director of the Department of Industry Development at the State Development Planning Commission[246], the most powerful agency in economic planning and governance over the energy and raw materials industries within the State Council. According to Liu, "rare earths are non-renewable resources, therefore they need to be protected and developed in a sustainable manner in order to maximize the strategic value. Rare earths are among the very few resources that China has an advantage in, and our generation needs to first protect the resource and then utilize the resource. The rare earth industry has problems including inefficient and extensive production, excessive and illegal mining, and inappropriate utilization and resource waste. We should change our strategies to protectively mine and use the rare earth resources, and to no longer just

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[244] Liu Tie'nan was a senior official in the State Development Planning Commission and the NDRC (reaching the post of Vice Chairman in 2008), working his way up from the Bureau of Raw Materials Industry in the State Planning Commission. Liu had considerable influence over the energy and raw materials industries in China, before he was investigated for corruption and sentenced to life in prison in 2013.

[245] The National Conference of Rare Earth Office Directors in 2002 convened directors of all rare earth offices within China's local governments after the 16th Party Congress of the Communist Party of China. Thus it served as a venue for the central party leadership to broadcast the development strategy defined by the Party to the local bureaucrats governing the rare earth sector in local regions.

[246] In the 1998 State Council reform spearheaded by Zhu Rongji, the State Planning Commission, formally the supreme agency responsible for economic planning and policymaking, was reorganized into the State Development Planning Commission, concentrating its administrative duties on macroeconomic policy making and market regulation. In the 2003 State Council reform spearheaded by Wen Jiabao, the National Development and Planning Commission was further reorganized into the National Development and Reform Commission (NDRC) through a merging with the State Council Office for Restructuring the Economic System and the State Economic and Trade Commission. NDRC gradually became the most powerful agency in the Wen-led State Council, in charge of formulating and implementing macroeconomic policies, setting prices for key commodity resources, and approving large-scale industry projects and investments. (U.S. China Business Council, 2014)

follow the old Swifter Extraction of Available Resources. We need to find a good place where it is best to realize the strategic value." (稀土是不可再生的自然资源，因此一定要保护好，要合理开发和使用资源，最大限度地发挥稀土资源的战略作用。稀土是中国为数不多的优势资源，我们这一代首先要保护好，其次是用好。稀土产业有粗放型发展的问题，有资源滥采的问题，也有利用不合理、资源浪费的问题。关于稀土资源的保护性开采和利用问题，我们要调整一下思路，不能"有水快流"。要找准它的位置，真正体现它的战略价值。) (Liu, 2002)

The state goal of sustainable development to maximize and preserve the rare earth resources' strategic value gained more momentum under the "Scientific Outlook on Development" (科学发展观) ideology of the Hu Jingtao/Wen Jiabao administration. In forming party ideologies, the Communist Party of China have traditionally extended orthodox Marxism-Leninism with the ideologies of China's own generations of party leadership, including the Mao Zedong Thought, the Deng Xiaoping Theory and Jiang Zemin's "Three Represents"[247]. Similarly, the "Scientific Outlook on Development" (SOD) ideology was introduced as an extension of party ideology by the Hu Jingtao/Wen Jiabao administration in 2003, the first year of its tenure. The "Scientific Outlook on Development" emphasized "a people-first approach, as well as an ideology of economic development that it should be well-rounded, sustainable and coordinated to ensure both

[247] Jiang Zemin, as China's post-Deng leader, was credited by the Communist Party as the contributor of the ideology of the "Three Represents". Jiang's speech at the 80th Anniversary of the founding of the Communist Party of China in 2000 stated that "our Party must always represent the requirements for developing China's advanced productive forces, the orientation of China's advanced culture and the fundamental interests of the overwhelming majority of the Chinese people. These are the inexorable requirements for maintaining and developing socialism, and the logical conclusion our Party has reached through hard exploration and great praxis." For more official definition, see http://cpc.people.com.cn/GB/64156/64157/4418474.html.

the quality and the speed of development (以人为本，全面、协调、可持续的发展观). (Xinhua, 2004) The Hu Jingtao/Wen Jiabao administration vowed to overturn the fixation on GDP-based economic growth, and to prioritize issues such as environmental and resource protection, social welfare and social equality along with economic development. (Central Committee of the Communist Party of China, 2005)

This party ideology spilled over to the state narrative on rare earth industry governance. Specifically at the 2004 National Conference of Rare Earth Office Directors, Xiong Bilin[248], then Vice Director of the Department of Industry at the National Development and Reform Commission (NDRC)[249], gave a speech entitled "Upholding and Implementing the Scientific Outlook on Development to Achieve the Sustainable Development of the Rare Earth Industry" (树立和落实科学发展观 实现稀土工业可持续发展). Xiong identified major obstacles to sustainable development of the rare earth industry as "the overcapacity of production, the lack of environmental protection, low resource utilization rate, and the lack of advanced applications and R&D". Xiong further

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[248] Xiong Bilin worked alongside Liu Tie'nan in the State Development Reform Commission before 2003, and after 2003 in the NDRC and after 2008 in the MIIT. Xiong oversaw policymaking in the raw materials industries, in particular the metallurgical industries. Xiong was put under "shuanggui" (extra-judiciary secret investigation by the CPC Central Commission for Discipline Inspection) in 2013, following the investigation and trial of Liu Tie'nan.

[249] The Department of Industry (工业司) at the National Development and Reform Commission (NDRC) was established after the 2003 transition from State Development Planning Commission to the NDRC, and was responsible for formulating and implementing policies in key raw material industries, including metallurgical industries. The department was dismantled in the 2008 State Council Reform, and its administrative duties and staff members were transferred to the corresponding industry departments within the Ministry of Industry and Information Technology (MIIT). Supervisory duties and staff members overseeing the rare earth industry, for instance, were transferred to the Department of Raw Materials Industries (原材料工业司) within the MIIT. (China Rare Earth Net, 2008; PRC Ministry of Industry and Information Technology, 2008)

identified four priority areas for the central government, among which two were directly related to the goal of sustainable development, namely "increasing and improving macro-level control over the industry production and export" and "promoting resource conservation and substitution". (Xiong, 2004)

7.2.2 Goals of State's Reregulation: Industry Upgrading

Besides the overriding goal of sustainable development (focusing mainly on resource and environmental conservation), the other main goal of state reregulation was to promote industry upgrading. As the previous chapter shows, in the late 1990s, China's production and export of high-value rare earth products were still small compared to the total volume and value of production and export. In addition, in specific high-tech applications such as the permanent magnets, China's production and export were subject to further restrictions due to the lack of domestic intellectual property. Thus from an economic perspective, in order to ensure long-term higher return for the extraction of non-renewable resources, the rare earth industry would need to develop domestic innovative technologies, to upgrade high-value production, and to produce and export more technologically advanced products that could compete in the global market. In terms of party rhetoric, the goal of fostering domestic technology innovation was also consistent with the party's broader strategy of "Indigenous Innovation" in guiding China's S&T development. According to Xiong Bilin's speech at the 2004 National Conference of Rare Earth Office Directors, besides the sustainable development areas of work, two other priority areas of work for the central government were "promoting industry restructuring and upgrading" and "promoting advancement in production technologies and high-tech applications". (Xiong, 2004)

7.2.3 Dual Emphasis of Market Expansion and State Control

The state development strategies to realize its reregulation goals continued to feature both state-sponsored expansion of the market economy and active state intervention in industry production. The continued focus on expansion of the market economy was aptly illustrated by President Jiang Zemin's address during a high-profile visit to Baotou in 1999. Jiang said that "in order to turn China's rare earth resource superiority into economic superiority, we must take advantage of the market. We must have the concept of the market as we develop socialist market economy. Without the market, we cannot develop our technologies, products and industries. We had success with the "Two Bombs and One Satellite" in the 1960s due to our concerted strength as a socialist country. We still need this kind of concerted strength to promote projects with significant strategic importance to China's comprehensive national power. To develop resources such as rare earth materials which have large market demand and can facilitate the growth of important industries, the key is to combine the resource advantage of China's rare earths with the market advantage, to develop advanced products with our own patented technologies, or to use our advantages to acquire advanced manufacturing technologies from abroad." (把我国的稀土资源优势转化为经济优势，必须结合我国的市场优势。我们发展社会主义市场经济，一定要有市场的观念。没有市场，技术、产品和产业都难以发展。20 世纪 60 年代，我们成功地搞出了两弹一星，依靠的是社会主义集中力量办大事的优势。发展这种对国家综合国力具有重大战略意义的项目，我们依然要发挥这种优势，对于像稀土材料这种市场有大量需求且可以形成重要产业的资源开发，一定要结合我国的市场优势进行。关键是必须把我国稀土

资源优势同市场优势结合起来，发展我们自己拥有知识产权的终端产品技术，或者利用我们的优势从国外获得先进制造技术) (Jiang, 1999)

At the same time the state continued to use broad five-year plans and specific industrial policies to intervene in market and industry growth. In 2000 the State Planning Commission released the *10th Five-Year Plan for China's Rare Earth Industry* (中国稀土工业“十五”发展规划). In this 2001-2005 plan, the central government outlined the specific development strategies to achieve reregulation goals. (PRC State Planning Commission, 2000)

1) Promote market expansion and high-tech applications (开拓市场，推广应用): the state would promote the application of REEs in both traditional industrial sectors as well as in high-tech sectors. In particular, the REE-enabled advanced materials including permanent magnets, high-function lighting materials, hydrogen storage materials and automobile catalytic converters would receive priority in state development plans.
2) Promote resource conservation and sustainable extraction (保护资源，合理开采): The state would prioritize the development of large-scale mineral deposits (the Baiyun-ebo mine in Baotou in North China and ionic-clay deposits in Jiangxi and Guangdong in South China). The state would curb illegal and over-capacity small-scale production. The state would promote the adoption of environmentally friendly mining and processing techniques to decrease pollution.

3) Control production and restructure industry supply (控制总量，调整结构): The state would control the total production volume and production capacity of both mining and smelting, in order to correct the chronic over supply in the market. The state would take steps to eliminate small-scale smelting plants, to ensure the economic scale of returns on resource extraction.
4) Plan projects to ensure appropriate distribution of projects at the national level (统一规划，合理布局): The state would halt the approval of new mining and smelting projects. The state would ban foreign investment in mining, impose restrictions on foreign investment in smelting projects. The state would encourage foreign investment in projects involving the rare earth applications.
5) Global strategy and intensive development (全球战略，集约发展): The state would promote the export of high-value products, while continuing restrictions on the export of primary products. The state would restrict the export eligibility to several large-scale rare earth companies, while ensuring fair export pricing.

The subsequent 11^{th} Five-Year Plan (2006-2010) also exhibited the state's dual emphasis on both supporting market expansion and intervening in industry development. In drafting the *11^{th} Five-Year Plan for the Rare Earth Industry*, Wang Caifeng, Chief of the Rare Earth Materials Bureau in the Department of Industry at the NDRC, wrote that the central government would focus on the following development strategies. (Wang, 2004)

1) Protect the environment to achieve sustainable utilization (保护资源，实现可持续利用). The state would increase efforts in environmental protection and resource conservation and seek to eradicate illegal mining.
2) Promote technology innovation for industry upgrading (技术创新，促进产业升级). The state would continue the support for the development of REE-enabled high-tech applications. The state would also increase the support for downstream high-tech industries using REE-enabled materials as raw materials.
3) Improve state governance to ensure orderly production within the industry (改善管理，促进行业运行现代化). The state would improve its regulation over the industry and improve policy coordination amongst state agencies. The state would also seek to improve the coordination of policy formulation and implementation with the local governments.
4) Promote industry self-governance and intensive development (加强自律，促进集约发展). The state would promote self-regulation within the industry and promote structural transformation so that companies would be motivated to protect their own corporate interests in alliance with the state goal of sustainable development. In particular, the state would promote corporate alliances of upstream mining and smelting producers with midstream and downstream applications producers, in order to ensure maximized returns on resource extraction within China.

7.3 Industry-Specific Regulatory and Policy Changes

To realize the goals of sustainable development and industry upgrading, the state enacted a series of industrial policies in this period to guide the development of the rare earth industry. This section surveys major legal regulations, administrative policies and state-sponsored initiatives specific to the rare earth industry from 1998 to 2007. The analysis of industrial policies are laid out in five areas, including industry production, trade and foreign investment, industry upgrading, industry structural consolidation and environmental protection.

7.3.1 Regulation on Industry Production and Domestic Investment

In order to avoid the overheated development which characterized the industry in the most of the 1980s and 1990s and to ensure long-term sustainable development of resource extraction, the central government imposed stronger restrictions on project approvals and investments related to the rare earth industry in this period. From 1999 until 2003, the Ministry of Land and Resources (MLR) discontinued issuing new licenses for REE mining. (PRC Ministry of Land and Resources, 1999; PRC Ministry of Land and Resources, 2000b) While the ban on licensing new projects was lifted in 2003, MLR conducted a 3-year nationwide inspection on mining projects focusing on the prosecution of illegal mining (PRC Ministry of Land and Resources, 2003) and published a list of eligible producers in 2005. (Rare Earth Office of the National Development and Reform Commission, 2005) In 2006, MLR again implemented a halt on new REE mining licenses. (PRC Ministry of Land and Resources, 2010)

Besides the upstream mining licensing halts and inspections by MLR, the State Council also recentralized project approval authority across the industry. In 2004 the

State Council released *Decisions of the State Council on Reforming the Investment System* (关于投资体制改革的决定). Specifically, REE mining projects, REE smelting projects, and above-100 million-RMB downstream production projects would require approval from the corresponding State Council ministries/commissions. Downstream production projects worth below 100 million RMB would need to be approved by provincial-level governments. (PRC State Council, 2003) This in effect removed the authority of local governments below the provincial level to approve new projects across the industry production chain.

The central government also began to use all-encompassing production quotas instead of production quota for specific REE products, in an attempt to curb the total volume of production. In 2006 MLR started issuing mining quotas for HREEs and LREEs to each major producing province. (PRC Ministry of Land and Resources, 2010) Also in 2007, the National Development and Reform Commission (NDRC) started issuing mandatory national production plans (国家指令性计划) instead of the previously used national production guideline plans (国家指导性计划) for rare earth primary products, namely concentrated ore products and smelting products. (Rare Earth Office of the National Development and Reform Commission, 2006) Following the transition of industry supervision from the NDRC to the Ministry of Industry and Information Technology (MIIT) in 2008, MIIT began to issue production plans for concentrated ores and smelting products to each major producing province. (PRC Ministry of Industry and Information Technology, 2008)

7.3.2 Regulation on Trade and Foreign Investment

While China has pledged to reduce its trade barriers after accession to the WTO in 2001, and rare earth products were not exempted from China's compliance with the WTO free trade rules, the rare earth industry has still been subject to export regulation by the central government. The export quota, export tariff and restrictions on foreign investment were imposed by the central government to enhance its control over industry production and individual companies, as well as to move China's export up the industry value chain.

7.3.2.1 Export planning and quota on rare earth products

The central government, specifically the State Economic and Trade Commission, continued to impose export planning on the rare earth industry. After the dismantling of the three trading companies controlled by the central government in 1998[250], the State Economic and Trade Commission started to allocate export plans to individual companies. Producing companies and trading companies needed to apply for the next year's export plan and pay for export licenses every year. (PRC State Economic and Trade Commission, 1999) On the other hand, to promote the production and export of the value-added products, the Ministry of Foreign Trade and Economic Cooperation abolished the export plan control for rare earth permanent magnets in 2000. (Rare Earth Office of the State Development Planning Commission, 2000) After China joined the WTO in 2001, rare earth primary products, along with other strategic commodity products including crude oil, petroleum products, coal and coke, were still subject to annual export plans allocated to by the State Economic and Trade Commission each eligible exporting company. (PRC State Economic and Trade Commission, 2002b) After

[250] The next section on political institutional changes provides detailed analysis of the institutional changes in state-owned enterprises in the rare earth industry in this period, including the state-led dismantling of the three trading giants in 1998.

the 2003 State Council reform which shifted trade regulation duties from the defunct State Economic and Trade Commission to the newly created Ministry of Commerce (MOFCOM), MOFCOM started issuing export quota to individual companies. (Chen, 2003) MOFCOM's annual evaluation of exporter eligibility and its distribution of export quota to each eligible exporter resulted over time in a smaller number of companies eligible for export to the global market. In 2006 MOFCOM's published roster of companies eligible for rare earth export was reduced to 44 companies. (PRC Ministry of Commerce, 2005a)

7.3.2.2 Export tariff on rare earth products

Apart from export quotas, the central government also removed the two-decade-long export tax rebates and started to impose tariffs on exports of various rare earth products. In 2005 the Ministry of Finance (MOF) abolished the export tax rebates for rare earth smelting products. (PRC Ministry of Finance & State Administration of Taxation, 2005) In November 2006 MOF imposed an export tariff of 10% on rare earth smelting products, including rare earth oxides, rare earth metals, rare earth chlorides and some other rare earth sodium products. (PRC Ministry of Finance, 2006b) In May 2007 an adjusted 15% export tariff was imposed on rare earth metals. (PRC Ministry of Finance, 2007)

7.3.2.3 Restrictions on foreign investment

Besides export quota and tariff, the central government also imposed significant restrictions on foreign investment in the upstream and midstream of the rare earth industry production chain. In 2002 the State Development Planning Commission released the *Regulations Regarding Foreign Investment in Rare Earth Industry*. The regulation removed the local governments' authority of approving foreign investment in downstream application projects that were higher than 30 billion dollars in value. The regulation also banned wholly-owned foreign companies from investing in rare earth mining and smelting, instead encouraging joint ventures and FDI in manufacturing of rare earth materials and downstream applications. (PRC State Development Planning Commission, 2002) The state also sought to ban foreign firms from using Chinese companies as upstream or intermediate producers supplying rare earth products, which would circumvent the government's export quota control. In 2005 MOFCOM prohibited the processing trade[251] of rare earth primary ores. (PRC Ministry of Commerce, 2005b) In 2007 MOFCOM further banned the processing trade of several rare earth smelting products, including rare earth oxides, rare earth metals, rare earth metal alloys and rare earth chlorides. (PRC Ministry of Commerce et al, 2007)

7.3.3 Industry Upgrading and Innovation Promotion

Besides regulations favoring value-added production and high-tech export that are outlined above, the central government also provided institutional support for upgrading production and promoting indigenous innovation of domestic rare earth companies. In 1999 Ministry of Science and Technology (MOST) established two centers to facilitate the R&D of small- and medium-sized rare earth firms in two major production regions, namely the Northern Rare Earth Industry Productivity Improvement Center (attached to the BRIRE) in Baotou[252] and the Southern Rare Earth Industry Productivity Improvement

[251] Processing trade (加工贸易) involves Chinese domestic firms obtaining raw materials or intermediate inputs from abroad, processing them locally, and exporting the value-added goods abroad.
[252] For more information, see the website of the Northern Rare Earth Industry Productivity Improvement Center at http://www.nreppc.com/.

Center (attached to the Ganzhou Non-ferrous Metallurgical Research Institute) in Ganzhou[253]. Also in 1999, the State Development Planning Commission approved a specialization of “Rare Earth High-tech Commercialization and Application Development” in project approval and financing. The State Development Planning Commission provided 0.3 billion RMB treasury bonds to the financing of projects. (Rare Earth Office of the State Development Planning Commission**,** 1999) In *2004 Guidelines for Priority of Development of High-tech Commercialization Areas* jointly released by NDRC, MOST and MOFCOM, the large-scale production of advanced rare earth materials (including high-performance rare earth permanent magnets) was listed as a priority area for development. (PRC National Development and Reform Commission et al, 2004) In *2005 Guidelines of Adjustment to Industry Structures* released by NDRC, the rare earth industry was broken down into the “downstream applications” that were filed under the “encouraged” category and the “mining and smelting” that were filed under the “restricted” category. (PRC National Development and Reform Commission, 2005)

It should be noted that unlike the upstream mining which was dominated by state capital, most of the downstream applications companies that developed to have sizable market share in this period were local companies established by private capital, or privatized local SOEs that went through privatization in the SOE reform. Unlike upstream mining, Beijing did not actively intervene in the market of rare earth applications by setting high bars for market entry or allocating production plans. In addition, state-owned companies did not make significant investment in downstream

[253] For more information, see the website of the Southern Rare Earth Industry Productivity Improvement Center at http://www.gzyjy.com.cn/guakaodanwei/2011-07-13/192.html.

applications such as rare earth permanent magnets, as the market for rare earth applications was still fairly small. Thus most of the capital that flowed into the rare earth downstream applications, such as permanent magnets, was private investment[254].

7.3.4 Structural Consolidation of Rare Earth Companies into National Conglomerates

While the three large state-owned trading groups in the rare earth industry were dismantled in the 1998 State Council reform, the central government started planning the consolidation of China's domestic rare earth industry into conglomerates with monopolistic/oligopolistic power in the market. The structural consolidation of the entire industry into large national corporate conglomerates was first proposed by scientists at the Chinese Academy of Sciences (CAS) in the early 1990s. A prominent rare earth chemist and CAS fellow Ni Jiazan published in *Bulletin of Chinese Academy of Sciences* in 1994 a well-read article entitled "Current Situation and Strategies for Rare Earth Research". Ni argued that China's resource advantage was compromised by the lack of domestic high-tech downstream applications, excessive small- and median-scale high-polluting mining production, cheap export of primary products, and the lack of centralized policy coordination and large-sized corporations capable of steering the market on the grand scale. (Ni, 2005, p. 221) Qian Xuesen, a prominent Chinese scientist known as the father of China's missile and space program, wrote a response letter urging the central government to "present a national strategic plan of using the rare earth resources, and then establish a monopolistic Chinese Rare Earth Corporation…China should become the leader of the rare earth industry in the world, much like the South

[254] Author interview with a senior manager at a major private rare earth magnet firm in Baotou, Inner Mongolia in August 2013.

African's domination in the diamond industry." (Ni, 2005, p. 223) Qian's letter was forwarded to then China's President Jiang Zemin by the former director of Baotou Metallurgical Industry Research Institute Li Guang, yet the proposal was not immediately acted upon by the central government. (Ni, 2005, p. 224) In 2000 under the directive of then Premier Zhu Rongji also heading the State Council, the State Planning Commission, the Ministry of Foreign Trade and Economic Cooperation, the Ministry of Finance, the Ministry of Science and Technology and the Ministry of Land and Resources jointly conducted research on macroeconomic regulation over the rare earth industry and reported their policy suggestions to the State Council. The recommendations to the State Council included propelling the industry onto the path of "new industrialization" and "intensive concentrated development" (Rare Earth Office of the State Planning Commission, 2000) In 2002 the State Economics and Trade Commission announced the plan to establish state-owned rare earth industry conglomerates. (PRC State Economic and Trade Commission, 2002c) An official plan of consolidating the industry into two conglomerates, one for North China and one for South China was approved by the State Council. The establishment of the North China Rare Earth Corporation Group, a conglomerate for LREE mining and smelting production, was started in 2002 and led by Inner Mongolia Rare Earth Corporation, a subsidiary company set up by Baotou Steel in 1999 to acquire smaller producers in Inner Mongolia. (Sichuan News, 2005) The establishment of South China Rare Earth Corporation Group, a conglomerate for HREE mining and smelting production, was started in 2002 and led by CHALCO (Aluminum Corporation of China), an SOE controlled by the central government. (Zhao, 2003) After the 2003 State Council Reform which dismantled the State Economic and Trade

Commission, the responsibility of overseeing the national restructuring of rare earth industry was transferred to the National Development and Reform Commission (NDRC). However, the negotiation between the central government, the leading SOEs, the local governments and the local rare earth companies over buying out local producers stagnated, and the plan was stalled by 2005. (Dai, 2005)

7.3.5 Environmental Protection and Resource Conservation

In line with the reregulation goal of sustainable development, the central government began to strengthen its environmental regulations in this period besides imposing various forms of control over production outlined above. In 2002, the State Bureau of Environmental Protection, the predecessor of the current Ministry of Environmental Protection, started drafting the standard for pollutant emission specifically for the nonferrous metal industries. Then in 2004 a special team was formed by the bureau to draft a pollutant emission standard specifically for the rare earth industry. The draft was released much later in 2009 and finally implemented in 2011. (PRC Ministry of Environmental Protection, 2009; PRC Ministry of Environmental Protection, 2011)

Expert input and investigative journalism also prompted the state to tighten its relaxed control over the environmental impact of the rare earth industry. In April 2005 the *Economy Time*, a prominent economics TV program on the China Central Television, aired an investigative journalism report on the damage to the water quality of the Yellow River from the pollution discharge of the rare earth industry in Baotou. Afterwards, the State Bureau of Environmental Protection conducted a joint inspection with the Inner Mongolia government over the rare earth companies in Baotou and ordered the over-polluting companies to temporarily halt production while improving their environmental treatment facilities. Environmental inspection over the rare earth mining and smelting companies were also conducted by the environmental protection authorities in the provinces of Jiangxi, Guangdong, Hunan and Sichuan. (Rare Earth Office of the PRC National Development and Reform Commission, 2005) In November 2005, a group of prominent scientists led by Xu Guangxian submitted a letter to the State Council on the high environmental casualties to the local environment from the radioactive Thorium waste from rare earth mining in the Baiyun-ebo region. The scientists called for restrictions on rare earth mining and national stockpiles for both REEs and thorium. The proposal suffered pushback from the Baotou Steel unwilling to curb its production; yet the National Development and Reform Commission responded after investigation that it would conduct studies on long-term stockpiles and extraction of both REEs and thorium from the tailings dam instead of new mining areas. (Chinese Academy of Sciences, 2005)

7.4 National-level Institutional Changes

This section analyzes the key political institutional changes in this period that influenced the implementation of state reregulation policies in the rare earth industry. The changes in political and legal institutions include weakened central bureaucratic institutions governing the SOEs, changes towards a multi-dimensional local cadre management system, and the lack of strong legal prosecution rules to prosecute illegal behavior under new rules. These political institutional factors contributed to China's sustained dominance in global rare earth production and trade, but also weakened the state's efforts in imposing production and export control over the localities to pursue long-term sustainable development.

7.4.1 State Council Reforms Decreasing Central Bureaucratic Control

Since the launching of the reform and opening up policy in 1978, the State Council has implemented institutional reforms almost every five years (1982, 1988, 1993, 1998, 2003, 2008, 2013) adjusting or dissolving old agencies and creating new ones. The State Council reform in 1998, under the direction of then Premier Zhu Rongji, was widely regarded as the most far-reaching among all six past reforms in changing China's bureaucracy. The following State Council reform in 2003, under the direction of then Premier Wen JIabao, also brought significant change to China's bureaucratic system. (PRC State Commission Office for Public Sector Reform, 2008)

As analyzed in the previous chapter, before 1998, the SOEs in the rare earth industry were in principle controlled by the central government through four bureaucratic authority systems (Ministry of Metallurgical Industry, China National Non-ferrous Metals Industry Corporation, China National Nuclear Company and China Minmetals Import & Export Company). In practice there was a considerable degree of overlapping administrative control over enterprise management between the central and local authorities in these four bureaucratic systems. These existing central bureaucratic authority systems underwent a whirlwind of significant changes after the State Council reforms. What used to be tight-knit bureaucratic authority systems were abolished or re-organized, weakening direct control capacity from the center. Companies and institutes formerly under central supervision were transferred to be supervised by the local governments, resulting in the transfer of assets and mining rights from the center to the local SOEs.

7.4.1.1 Abolishment of the Ministry of Metallurgical Industry

The Ministry of Metallurgical Industry was abolished in the 1998 State Council reform. As the previous chapter shows, until 1998 the Ministry of Metallurgical Industry was the primary industry-specific ministry overseeing China's metallurgical industries (mostly focused on steel instead of non-ferrous metal production). After the abolishment of the ministry, the Bureau of Metallurgical Industry within the State Economic and Trade Commission temporarily performed regulatory functions between 1998 and 2001 (when the bureau was also abolished). Between 2001 and 2003 regulatory functions over metallurgical industries were carried out by the State Economic and Trade Commission. After the abolishment of the State Economic and Trade Commission in the 2003 State Council reform, regulatory functions were split between several new ministries, including MOFCOM, NDRC and SASAC.

In the rare earth industry, prior to 1998 the Ministry of Metallurgical Industry directly supervised key state-owned players including Baotou Steel (包头钢铁) and China Metallurgical Import & Export Company (CMIEC, 中国冶金进出口总公司). Both went through shareholding reforms, and Baotou Steel was transferred to be supervised by the Inner Mongolia local government, while CMIEC became part of a central SOE. Baotou Steel Rare Earth Company, the rare earth subsidiary of Baotou Steel, went through a shareholding reform in 1997 and became a shareholding company named Baotou Steel Rare Earth High-tech Company Limited. The notable research institute in the rare earth industry, Baotou Research Institute of Rare Earths (BRIRE) became a subsidiary of this new firm. According to the IPO (Initial Public Offering) Prospectus

Report and 1998 Annual Report[255], Baotou Steel Rare Earth High-tech Company Limited was primarily controlled by three stockholders: The largest shareholder was Baotou Steel, which was transferred from the Ministry of Metallurgical Industry to be under local government (Inner Mongolia Autonomous Region Government) supervision in 1998. The second largest shareholder was Jiaxin Steel, a Hong Kong-based private metal trading company owned by Chen Ningning (Diana Chen), a U.S.-educated investor known in China as the "Steel Princess" and the granddaughter of Former Minister of Metallurgical Industry Lv Dong[256]. The third largest shareholder was Shanghai Baosteel, a steel SOE now directly controlled by the central government through SASAC.

China Metallurgical Import & Export Company, one of the three trading groups approved by the central government to export rare earth products in the 1990s, ended up becoming a trading subsidiary of a central SOE. CMIEC became part of Sinosteel Trading Company (中钢贸易), an iron ore import company directly controlled by the Ministry of Metallurgical Industry in 1995. After the abolishment of the Ministry of Metallurgical Industry in 1998 and the split of the State Economic and Trade Commission in 2003, Sinosteel Trading Company went through a shareholding reform

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[255] The IPO Prospectus Report can be accessed at http://stock.jrj.com.cn/share,600111,ggcontent.shtml?discId=00000000000000nu3j. The 1998 Annual Report can be accessed at http://q.stock.sohu.com/cn,gg,600111,363233.shtml.

[256] Although Chen rarely gave media interviews and played down her personal connection with her prominent bureaucrat family in Beijing in the official interviews, she was well known in China between early 1990s until 2008 as the "Steel Princess". The Hong Kong-based trading company Jiaxin Steel founded by her and her mother (Lv Dong's daughter) in the early 1990s quickly grew to become the largest private iron ore trading company in Greater China and was occupying more than 15% of China's iron ore import volume by 2003. Jiaxin Steel suffered significant financial losses in the 2008 global financial crisis and reportedly filed for bankruptcy in 2013. For more information, see her open media interview by People's Daily at http://paper.people.com.cn/rmrbhwb/html/2007-10/13/content_24602706.htm.

and became a trading subsidiary of Sino Steel Corporation (中钢股份), a central SOE directly controlled by SASAC[257].

7.4.1.2 Split of China Non-ferrous Metals Industry Corporation and Nationwide Corporate Reorganization of Non-ferrous Metals Companies

As analyzed in the previous chapter, China National Non-ferrous Metals Industry Corporation (中国有色金属工业总公司) was established by the State Council in the early years of reform and opening up as a national company covering China's non-ferrous metals production. It had the same bureaucratic rank with the State Council ministries and was directly responsible for managing the non-ferrous metals industry for the State Council. China Non-ferrous Metals Import & Export Company, the trading arm of the China Non-ferrous Metals Industry Corporation was one of three eligible exporters of rare earth products. In other words, China Non-ferrous Metals Industry Corporation was both a gigantic state-owned enterprise group as well as a policy making and implementing bureaucracy.

This centralized bureaucratic system known to industry professionals as "Non-ferrous Metals Industry System" (有色金属工业系统) was dismantled in the 1998 State Council Reform under then Premier Zhu Rongji's strategy of "Separating the Bureaucracy and the Enterprise"(政企分开). The administrative part of the Non-ferrous Metals Industry System formed a transitory regulatory agency named Bureau of National Non-ferrous Metals Industry (国家有色金属工业局) under the State Economic and Trade Commission. The State Council further abolished the Bureau of National Non-

[257] For more information, see the company website at http://trading.sinosteel.com/gsgk/fzlc/index.shtml.

ferrous Metals Industry in 2001 and transferred its regulatory functions to a newly-created quasi-governmental industry association named China Association of Non-ferrous Metal Industry (中国有色金属工业协会). In this way, at least on paper the State Council achieved the separation of bureaucracy and the enterprise; instead of directly owning and controlling the companies in the non-ferrous metals industry, the ministries in the State Council would work with the industry association which served as the representative of non-ferrous metals companies. (Wang, 2001)

In the 1998 State Council reform, the corporate part of the Non-ferrous Metals Industry System were split into three central SOE corporate groups in charge of businesses in specific nonferrous metals, namely China Copper Lead Zinc Group (中国铜铅锌集团), China Aluminum Group (中国铝业集团公司) and China Rare Metals and Rare Earth Group (中国稀有稀土金属集团公司). (PRC State Council, 1998; PRC State Council, 1999b; PRC State Council, 1999c; PRC State Council, 1999d) Then a year later, in 2000 the State Council further dismantled the three central SOE groups. China Aluminum Group was abolished and most of its subsidiaries became local SOEs, but the central office retained the companies in several key production regions and formed a new SOE named the Aluminum Corporation of China (中国铝业), now known as CHALCO[258]. China Rare Metals and Rare Earth Group was abolished and all its subsidiaries became local SOEs supervised by local governments. (PRC State Council, 2000b) China Copper Lead Zinc Group was also abolished and all its subsidiary companies became local SOEs supervised by local governments. (PRC State Council,

[258] CHALCO has remained a central SOE and been directly supervised by the central government through SASAC since 2003.

2000b) The local trading subsidiaries of China Non-ferrous Metals Import & Export Company were transferred to become independent trading companies supervised by local governments, or joined the local SOE spin-offs of the three defunct central SOE corporate groups. The central office and operations of China Non-ferrous Metals Import & Export Company was merged into China Minmetals. (PRC State Council, 2000b; PRC Ministry of Finance & Generation Administration of Taxation, 2000)

For the rare earth companies in particular, the State Council reform measures from 1998 to 2000 split their bureaucratic umbrella organization of China National Non-ferrous Metals Industry Corporation into a few new central SOEs and a much larger number of local companies. As many local producing and trading subsidiaries were transferred to be supervised by local governments, local governments were given the right to tax the SOEs that were transferred to be under their control and to retain the corporate income tax as local government revenue. The process of state assets transfer from the central government and central SOEs to the local government and local-government-controlled SOEs was not without contentions. Particularly concerning the upstream of the industry (mining), because the Ministry of Land and Resources discontinued issuing new mining licenses in 1999-2003, existing mining licenses and accompanied mining rights became the target assets for grab between the local governments eager to capture them and the central SOEs still fighting to retain them. The Chinese political institutions operate within a hierarchical system of ranks: administrative units at a lower rank have less authority than units at a higher rank. Local provincial governors and party secretaries have the same political rank of authority with the ministers of ministries in the State Council; local prefecture mayors and party secretaries have the same political rank of authority with the chief of bureaus in State Council ministries. Thus central ministries and SOEs were at an even playing ground with the local governments. Local provincial governments sought to merge the mining rights and the assets previously belonging to central actors into local-government-owned SOEs. What emerged were new market actors with complex ownership structures and names that may not exactly match their new owners or operations. Below is a breakdown of the changes in key market actors in the rare earth industry by province.

Jiangxi Province: After the split of the China National Non-ferrous Metals Industry Corporation, the local provincial and prefecture governments consolidated spin-off local non-ferrous metal companies and mining rights into local SOEs. Firstly, the Ganzhou Prefecture Government declared exclusive mining rights and obtained all rare earth mining licenses within the Ganzhou Prefecture, a major production prefecture in Jiangxi Province. In 2004 the prefecture government established a prefecture-level SOE called Ganzhou Prefecture Rare Earth Mining Company, now known as Ganzhou Rare Earths (赣州稀土)[259]. In actual practice though, mining operations at more than 80 legal mining sites in different counties below the prefecture operated almost independently, and Jiangxi Rare Earths was described by local businessmen as no more than the "invoice biller" for local rare earth mines[260]. Secondly, the Jiangxi Provincial Government consolidated the tungsten, tantalum and niobium companies transferred from China National Non-ferrous Metals Industry Corporation into a new provincial-level state-owned shareholding firm named Jiangxi Rare Metals & Tungsten Corporation Group,

[259] For more information about the history of the founding of Ganzhou Rare Earths, see the company website at http://www.gz-re.com/about/qyjj/about.html.
[260] Author interview with local businessmen in Ganzhou, Jiangxi Province in July 2013.

now known as Jiangxi Tungsten Group (江钨集团). With bureaucratic support from the Jiangxi Provincial Government, this newly formed provincial-level SOE was able to consolidate and obtain the rare earth mining licenses in remaining areas of Jiangxi Province in 2001. These mining licenses originally belonged to a subsidiary of China National Non-ferrous Metals Industry Corporation, Jiangxi Tungsten (confusingly the same name) whose assets were first transferred to China Minmetals after the split. In other words, China Minmetals lost the mining rights and licenses to Jiangxi Tungsten Group which was supported by Jiangxi Provincial Government. (Liu, 2010) Thirdly, the Jiangxi Provincial Government consolidated the copper and other major precious metal companies transferred from China National Non-ferrous Metals Industry Corporation into a provincial state-owned shareholding firm named Jiangxi Copper Group (江铜集团). Although Jiangxi Copper Group did not obtain rare earth mining licenses/assets in Jiangxi, it purchased a rare earth mining license in Sichuan Province and gained the mining rights for deposits in Sichuan in 2008. (Wei, 2008)

Guangdong Province: After the split of the China National Non-ferrous Metals Industry Corporation, the Guangdong Provincial Government consolidated most spin-off local non-ferrous metal companies into a newly created provincial state-owned shareholding firm named Guangdong Rising Non-ferrous Metals Group (广东广晟有色金属集团)[261]. The largest shareholder of this provincial SOE was Guangdong Rising Assets Management Company (广东省广晟资产经营有限公司), a provincial-level asset management SOE wholly owned by the Guangdong Provincial Government. The

[261] For more information about the founding of Guangdong Rising Non-ferrous Metals Group, see the company website at http://www.gdrising.com.cn/.

Guangdong subsidiary of China Non-ferrous Metals Import & Export Company (the trading arm of China National Non-ferrous Metals Industry Corporation) was also consolidated into Guangdong Rising Non-ferrous Metals as its trading subsidiary. In the rare earth mining, Guangdong Rising Non-ferrous Metals held 3 of the 4 existing rare earth mining licenses in Guangdong Province. (Xiao, 2011) The remaining one rare earth mining license was approved for mining in Heyuan Prefecture and was controlled by Guyun Rare Earth Mining Company, a local company established by the Heyuan Prefecture in 2001.[262]

Fujian Province: In Fujian Province, the split of China National Non-ferrous Metals Industry Corporation in 1998-2000 produced insignificant change, as the Fuzhou subsidiary of China National Non-ferrous Metals Industry Corporation (established in 1984) was a name plate that shared office and staff (一套机构两块牌子) with an already existing provincial-level company, Fujian Province Metallurgical Industry Corporation (福建省冶金工业总公司). Fujian Province Metallurgical Industry Corporation was set up in 1983 as a corporate replacement of the abolished Bureau of Metallurgical Industry of the Fujian Provincial Government (福建省冶金厅). The corporation had the same bureaucratic rank and authority with other bureaus in the Fujian Provincial Government. (Fujian Province Local Chronicle Database, 2002; Fujian Province Local Chronical Editorial Commission Office, 2002) Most local non-ferrous metals companies in Fujian Province were prefecture-level or county-level companies supervised by Fujian Province Metallurgical Industry Corporation. In the rare earth industry, five rare earth mining

[262] For more information about the company Guyun Rare Earth Mining Company, see the company website at http://www.hyhuada.com/about/?18.html. Guangdong Rising Non-ferrous Metals would later in 2011 acquire 80% of the total shares of Guyun Rare Earth Mining Company and thus acquire all rare earth mining licenses in the province.

licenses were granted by Fujian Provincial Government in the 1980s. (PRC Ministry of Land and Resources, 2012) Shanghang County in Longyan Prefecture was granted one mining license in 1987 and set up a county-level company named Zhaorui Mining to conduct mining in the approved area. Liancheng County in Longyan Prefecture was granted two mining licenses in 1987 and 1988 and set up two county-level companies, Dingcheng Rare Earth and Huangfang Rare Earth to conduct mining for the two mining sites. Changting County in Longyan Prefecture was granted one mining license in 1989 to conduct mining in the approved area. The central-government-owned SOE, China Minmetals acquired control over one rare earth mining license in 1989 through its subsidiary Sanming Rare Earth Materials Company, a joint investment with Sanming Prefecture. In 2000 Fujian Province Metallurgical Industry Corporation went through a shareholding reform and became Fujian Metallurgical Company Ltd. (福建冶金控股有限公司) wholly owned by the Fujian Provincial Government[263]. Fujian Metallurgical Company continued to leave the direct control over the five rare earth mining licenses to prefecture-level and county-level rural companies. In 2003 Changting County sought major investment from Qiandong Rare Earth Group (虔东稀土), a local rural private cooperative company based in Qiandong County in Ganzhou, Jiangxi Province which in turn acquired control over this mining license[264].

7.4.1.3 Central SOEs Dropped out of Upstream Mining

[263] Fujian Metallurgical Company was granted full or majority share of all provincial-level metallurgical SOEs, guaranteeing the provincial government continued control over them.

[264] For more information, see the company website of Qiandong Rare Earth Group at http://www.jxgqd.com/Taocan.aspx?id=2.

The key central SOEs emerged out of the split of China National Non-ferrous Metals Industry Corporation in 1998-2000 included CHALCO (中国铝业), China Minmetals (中国五矿) and China Non-ferrous Mining Group (中国有色矿业集团). Compared to the local SOEs, the central SOEs acquired much fewer upstream mining licenses or resources. CHALCO was built in 2000 to focus on aluminum and did not obtain new assets in the rare earth industry. As the previous chapter shows, China Minmetals began to acquire metal production companies to complement its trading business after the 1988 "Reform of the Foreign Trade Institution". After 2000 China Minmetals was able to retain the mining subsidiary in Fujian Province, and it also strengthened its trading business through acquiring the head office of the China Non-ferrous Metals Import & Export Company. Yet China Minmetals lost the mining licenses in the crucial province of Jiangxi to Jiangxi Tungsten Group after the bitter battle with Jiangxi Provincial Government over mining rights and asset ownership, and as a result it had to set up smelting and downstream subsidiaries in Ganzhou in exchange for resources with Ganzhou Prefecture Government. (Liu, 2010) China Non-ferrous Mining Group, now known for short as China Non-ferrous Metals (中国有色), should not be confused with the former system bearing almost the same name: this new China Non-ferrous Metals was built from subsidiary units of China National Non-ferrous Metals Industry Corporation's overseas construction operations, and thus it did not have any rare earth mining licenses or mining subsidiaries[265]. China National Nuclear Company, which had subsidiaries producing rare earth products along with the coexisting radioactive elements

[265] See the introduction of the founding of the company at the company website at http://www.cnmc.com.cn/outline.jsp?column_no=0102

of Thorium and Uranium, did not control any rare earth mines and significantly downsized its rare earth production after 2006 to concentrate on nuclear power[266].

It would come as no surprise that the central government's later plan of restructuring the rare earth industry into two national state-owned conglomerates from 2002 until 2005 turned out to be an attempt in vain. CHALCO, the chosen central SOE leader, had no mining licenses and no bargaining power except the guarantee of production quotas and export quotas from the State Council to the local SOEs if they became part of a central SOE. Once local SOEs saw no imminent threat to the allocation of production and export quotas, CHALCO lost the bargaining chip to convince the local companies and their local government backers to join a central-government-owned rare earth conglomerate. (Dai, 2005a; Dai, 2005b)

7.4.1.4 Lack of Coordination among Central Government Agencies

The 2003 State Council reform led by then Premier Wen Jiabao resulted in further fragmentation of supervision over the rare earth industry within the central bureaucracy. Earlier in the 1998 State Council reform, the State Planning Commission, formally the supreme agency responsible for economic planning and policymaking, was reorganized into the State Development Planning Commission, concentrating its administrative duties on macroeconomic policy making and market regulation. Then in the 2003 State Council reform, the State Development Planning Commission was further reorganized into the National Development and Reform Commission (NDRC) through a merging with the State Council Office for Restructuring the Economic System and the State Economic and

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[266] In 2006 China National Nuclear Company changed the name of the subsidiary China Nuclear Industry Rare Earth Company into China Nuclear Power Engineering Company. See the introduction of the history of the China Nuclear Power Company at http://www.cnpe.cc/tabid/859/Default.aspx.

Trade Commission. (Xinhua, 2013) NDRC gradually became the most powerful agency in the Wen-led State Council, in charge of formulating and implementing macroeconomic policies, setting prices for key commodity resources, and approving large-scale industry projects and investments. (U.S. China Business Council, 2014) Besides the supra-agency NDRC setting high-level agendas and approving industry projects, a few other central government ministries also had supervisory role over part of the rare earth industry: MOFCOM was responsible for issuing export licenses and export quota, and General Customs was responsible for export inspections; MOF was responsible for taxation on production and export as well as funding for government-funded programs; MLR was responsible for issuing mining licenses and mining quota and conducting inspections on mining activities; MEP was responsible for issuing environmental and occupational safety regulations and conducting inspections; SASAC was responsible for directly overseeing the state assets and personnel appointment of key central SOEs. The Rare Earth Office, the direct supervisory office over the rare earth industry in the 1980s and 1990s, was transferred to be a division (at the same bureaucratic level with a county) within the NDRC, and its responsibility was reduced to the coordination of policy matters over the rare earth industry between the central government agencies. The office's low ranking within Chinese political system (two levels below the ministry) meant that its coordination authority was weak, if non-existent. There were "frequent instances where one ministry's policy documents or targets trumped another ministry's policy". (Fang, 2010a) For instance, some producing companies complained that MOFCOM's export quota allocated to them was disproportional relative to the production capacity of the industry projects already approved by the NDRC. In 2003 MOFCOM allocated more than 50% of total export quota to trading companies and less than 25% of total export quota to local rare earth producers. (Chen, 2003) This forced some smelting producers, particular local companies with large production capacity and export demand in major production provinces of Jiangxi and Inner Mongolia to buy surplus quota from trading companies in order to fulfill contracts and export products. (Wei, 2004; Ji, 2004) This illegal trading of export eligibility led to the creation of a black market for export quota; as a result, trading companies with export quota but no production capacity could make great profits selling surplus quota to the producers, creating essentially an added tax over the local producers. By 2006, the export quota was traded on the black market at 4000 RMB per ton. (Xinhua, 2006b) To make things worse, because one of MOFCOM's export quota evaluation criteria was the volume and the revenue of export in past three years, those with insufficient export quota were stuck with this disproportional allocation. (China Rare Earth Net, 2006)

7.4.2 Changes in Local Cadre Promotion System

Addressing the issues of local nepotism, GDP fixation and ineffective supervision and auditing which emerged in the previous period, the party leaders implemented internal institutional changes in local cadre promotion system after 1998. The changes influenced the state-industry relationship and indirectly influenced the development of the rare earth industry in this period.

7.4.2.1 Vertical Management of Local Cadre Appointment in Market and Land Regulation

The party sought to strengthen its power over managing local cadres in key areas of the economy through "vertical management". As the previous chapter shows, the "One

Level Downward" cadre management model where the party authorities would only appoint and remove cadres at the next lower level has been implemented since 1983 to promote administrative efficiency. To curb local nepotism the "dual management" of local cadres has been implemented since 1991 to allow for dual control over the local cadres by both the local party committee and the higher-level ministry/bureau.

Between 1998 and 2008 the central leadership sought to expand dual management areas subject to "vertical management", where the central ministry or the provincial-level bureau have primary power of appointing and managing personnel at all local bureaus instead of the local party committee. The expansion of vertical management areas particularly targeted the supervision of local market actors as well as the regulation over local land use. This was in response to the rampant local protectionism over local market actors ignoring central government regulations in the previous period of the 1980s and 1990s, when local cadre promotion and appointment were heavily reliant on strong local economic growth statistics. (Li, 2012) In 1998 the Central Party Committee and the State Council jointly announced that the local Administration for Industry and Commerce (工商管理机关, AIC) below the provincial level would be subject to "vertical management" by the provincial Administration for Industry and Commerce. (PRC State Administration for Industry and Commerce, 1999) In 2004 the Ministry of Land and Resources announced that land use approval as well as appointment of local MLR officials would be subject to "vertical management" by the provincial Bureau of Land and Resource. (Yu, 2006)

7.4.2.2 Changes in Local Cadre Evaluation and Promotion Criteria

Without fundamental changes in the GDP-fixated criteria for local cadre evaluation and promotion, putting local bureaucracy under vertical personnel management would be akin to putting a bandage on the issue of local non-compliance without treating the cause. Thus changes in the incentive structure in local cadre evaluation and promotion would be fundamentally more important. Yet after 1998 local cadre promotion still relied heavily on economic measures including GDP growth and investment, and the competition between cadres of different regions resembling a "promotion tournament" was still vital in most parts of China. (Zhou, 2007) In 2004 the State Bureau of Environmental Protection started a project calculating the "Green GDP", measuring local economic growth combined with the environmental record, a metric similar to the internationally accepted System of Environmental-Economic Accounting (SEEA). However, the project suffered significant pushback in the pilot provinces and cities, where government officials were strongly against releasing the data; in Shanxi Province for instance, provincial government officials were reportedly "enraged that the results showed they barely had any progress". The "Green GDP" project was halted ever since until 2015. (Ye, 2015)

On the other hand, in local cadre evaluation there was an increasing focus on the social welfare and harmony, which corresponded to one of the Communist Party's new goals of "building a socialist harmonious society" after 2004[267] (构建社会主义和谐社会). In particular, the measures of social stability, usually by the number of public

[267] At the 4th Plenary Session of the 16th Central Committee of the Communist Party of China, the Central Committee declared that "building a socialist harmonious society" would be one of the five areas where the Communist Party would improve its governance. See the Party Communique at http://news.xinhuanet.com/newscenter/2004-09/19/content_1995366.htm.

protests (群体性事件) and by the number of citizen complaints to the higher authority (上访), were given more prominence in evaluating the performance of local cadres. (Wu & Ma, 2009)

Thus the labor-intensive, pollution-laden production driven by short-term calculation of profits (often illegal under central policies), characteristic of many local businesses in the rare earth industry, became a mixed recipe for local cadre promotion. In the eyes of the local cadres, the rare earth businesses were not only profit-boosters for their record of fostering local economic growth, but also potential scars on their record of maintaining social stability. Widespread environmental degradation, health hazards due to long-term exposure to toxic and radioactive waste, displacement of local people due to the encroachment of farm land, lack of equitable profit distribution (cadres making significant cut of the profit), and negligence of labor rights[268] were the primary reasons for public discontent. (Nanfang Daily, 2005; Huang, 2007; Ruttinger & Feil, 2010; China Development Research Foundation, 2011) The temporary high profit of rare earth businesses were vital to both career promotion, local government revenue and often personal wealth of local county and village cadres. For instance, In Anyuan County, a major producing county in Ganzhou Prefecture, buying and owning shares of local rare earth businesses was common among local cadres; it was only natural that they wanted their slice of the profit pie while offering protection as the local authority[269]. Local cadres were inclined to abuse their power, offering protection (such as armed guard, low land rents) to the local rare earth business operations while suppressing publicly displayed

[268] Based on author's fieldwork in Jiangxi Province, it was common practice in the local rare earth businesses that workers wear no or minimal protective clothing or mask when working with hazardous chemicals, fumes and dust.
[269] This observation was based on author's field work in Ganzhou Prefecture.

discontents of local villagers. In some counties in Guangdong Province and Jiangxi Province, local cadres were reportedly involved in organized crimes arresting protestors and petitioners and were covering up raids against the protestors by “thugs” hired by local businesses or by “gangs” with ties to the local cadres. (Bradsher, 2009; Hilsum, 2009) Thus contrary to Beijing’s intention of balancing economic growth with social welfare, in practice the changes in incentive structure in local cadre promotion led to cover up of environmental casualties and social conflicts, and they did little to combat local cadre corruption or non-compliance with legal rules and central policies.

7.4.2.3 Cadre Monitoring and Evaluation

As the previous chapter shows, the auditing, discipline inspection and supervision institutions set up by the central government to monitor and evaluate the performance of local governments served as a “last line of defense” against local cadre corruption and non-compliance, yet their effectiveness was significantly reduced under the “dual management” system. Between 1998 and 2008, the central party authority implemented some measures strengthening higher-level control over cadre monitoring and evaluation institutions, yet the measures were still far from enough to ensure their effectiveness.

In terms of the auditing institution, the local auditing bureaus were still subject to dual management under both the higher-level auditing authority and the local party authority; what was worse, in practice the direct local party official overseeing the auditing bureau often ranked lower than the local party official overseeing government budgets, making it impossible for local auditing officials to conduct independent auditing. (Yang et al, 2008) A survey of the members of the China Auditing Society in 2002 concluded that 86% of its members rated “lack of independence” as the most significant issue in China's auditing institution, 76% rated "lack of authoritative data" and 73% rated "lack of transparency" as a significant issue. (Yang et al, 2003) As a result of this inability to conduct independent and transparent audits, government funding allocated to specific projects such as environmental treatment or conservation was often appropriated for use in other development projects by local governments with little repercussions. (Ma et al, 2001; Economy, 2007; Gang, 2009)

In terms of discipline inspection and supervision institutions, the lack of independence leading to ineffectiveness as manifested in the prior period still persisted after 1998. Local discipline inspection and supervision personnel were managed by local party committees who controlled their administrative budgets, promotion, salaries and retirement benefits, thus continuing the dilemma of "supervising and monitoring their own managers". (Gong, 2009; Guo, 2007) Because local discipline inspection and supervision personnel were treated as part of the entire local bureaucracy (the head of the local discipline inspection commission also served as a core member of the local party committee), inspectors were also often allocated responsibilities as the party committee saw fit to other governance areas, ranging from handling resident complaints to inspecting local industry production to supervising family planning and birth control. (Liu & Li, 2014) In some counties with targets for economic and investment growth, local inspectors were also given tasks of bringing in investments and development projects. This multitasking led to not only decreased work efficiency, but also created the inherent conflict of being "the coach, the athlete and the referee" in local economic affairs. (Liao & Li, 2008) The central leadership did step up its efforts using "dispatched inspectors" to monitor the work of party cadres in government and state-owned enterprises. (Li, 2015) In 2004, the CPC Central Commission for Discipline Inspection announced that the dispatched inspectors to central ministries by the Central Commission for Discipline Inspection would be under the direct guidance of the Central Commission for Discipline Inspection/Ministry of Supervision. (CPC Central Commission for Discipline Inspection et al, 2004) Similar changes were implemented at the provincial and prefectural level: inspectors dispatched to government bureaus or state-owned enterprises at provincial and prefectural levels would be only under the guidance of provincial and prefectural discipline inspection commissions. Yet because the dispatched inspectors received administrative expenditures, salaries and benefits from the bureaus/enterprises they were inspecting on, the dispatched inspectors could not perform monitoring or evaluation fully independently. (Guo, 2013)

7.4.3 Lack of Strong Legal Institutions to Persecute Illegal Activities

The lack of strong legal rules to persecute against illegal activities (i.e. illegal mining, smuggling, illegal trade of quota, etc.) deemed under the new rules imposed by the state also made enforcement of state mandates more difficult. Take illegal mining as an example: prosecution was ineffective due to miniscule penalty charges and inefficient prosecution procedure. MLR suspended new mining license applications from 1999 until 2003 and again from 2005. MLR also vowed to close all unlicensed operations that violated industry and environmental standards during nationwide inspections between 2003 and 2005. MLR's efforts led to large areas with rare earth deposits untapped. In Guangdong Province and Fujian Province for instance, the existing rare earth mining licenses were all released before 2001 and covered a small part of the provincial areas with rare earth deposits. With no hope from the MLR on either approving/restoring license applications or the enlargement of mining areas, local businesses and individuals pursued mining without valid licenses or flocked to pursue mining in the unapproved areas, leading to rampant illegal mining and smuggling.

According to a local bureau of land resources official in Xingfeng County in Jiangxi Province, during inspections local bureau of land resources enforcement officers could only "damage the machinery but not arrest illegal mine operators", and illegal mine operators often could flee to another region to continue production or "come back after they bribed someone of authority". Prosecution of illegal mining would only be possible "if the mine region was larger than 10 *Mu*"; however, "by the time the procedures for identifying the mining area and evidence were completed, the suspect had already extracted rare earth ores using replaced machinery, sold the goods and fled the region". (Li, 2011)

Even if a suspect was captured by local police and then persecuted in the local court, he or she would typically only get less than 3 years of jail time. Compared to the potential of windfall profits in good years of market demand (priced at several hundred thousand RMB per ton compared to only around 20,000 RMB per ton in set-up cost), many local businessmen would gladly choose to break the law and use part of the illegal earnings to bribe for protection from local government cadres[270].

7.5 Industry Development Outcomes

The previous sections analyze the macroeconomic environment, state reregulation goals and industry-specific policies and political institutional changes from 1998 to 2007. This section analyzes the outcomes of state reregulation in comparison with the state's

[270] Author interviews with local businessmen in Ganzhou, Jiangxi Province in July 2013.

goals and policy targets. Industry development outcomes are assessed in four areas: industry production and consumption, international trade, market structure and environmental and social impact.

7.5.1 Industry Production and Consumption

7.5.1.1 Mine Production

In this period between 1998 and 2007, China's rare earth mining output has dominated the global market supply and exceeded the official quota set by the central government. As Figure 44 shows, China rare earth concentrate output already accounted for about 90% of global output in 1998-2002, and after 2002 more than 96% of global output. China's dominance in global REE mine production was partially aided by the closure of Molycorp. In 1998 the U.S. primary producer Molycorp's production of refined rare earth compounds was ceased due to a blocked wastewater pipe and a series of wastewater leaks which spilled radioactive wastewater into the Ivanpah Dry Lake. (Hedrick, 1999) Decreasing revenues due to strong Chinese competition and the high cost of environment remedy projects to clean up the spill made Molycorp's production costly and difficult to maintain. The Mountain Pass mine officially ceased mining production in 2002, ending the U.S. mining of REEs. (Margonelli, 2009) In terms of production relative to global demand, China became the default supplier country for the global market. As Figure 45 shows, China's mining production grew to be almost on par with the global demand in 1998, and its mining production remained either on par or larger than the global demand by 2007.

While the Ministry of Land and Resources imposed multiple mining licensing halts and inspections in this period and also began to issue production quota in 2006, the result was over-production compared to the state-imposed goals as shown in Figure 46. The actual overcapacity of production was likely to be even higher, as the production statistics was taken from official sources and could not take into account illegal mining output that were also consumed locally and not reported. Thus we can conclude that the production restrictions did not work as well as the state intended.

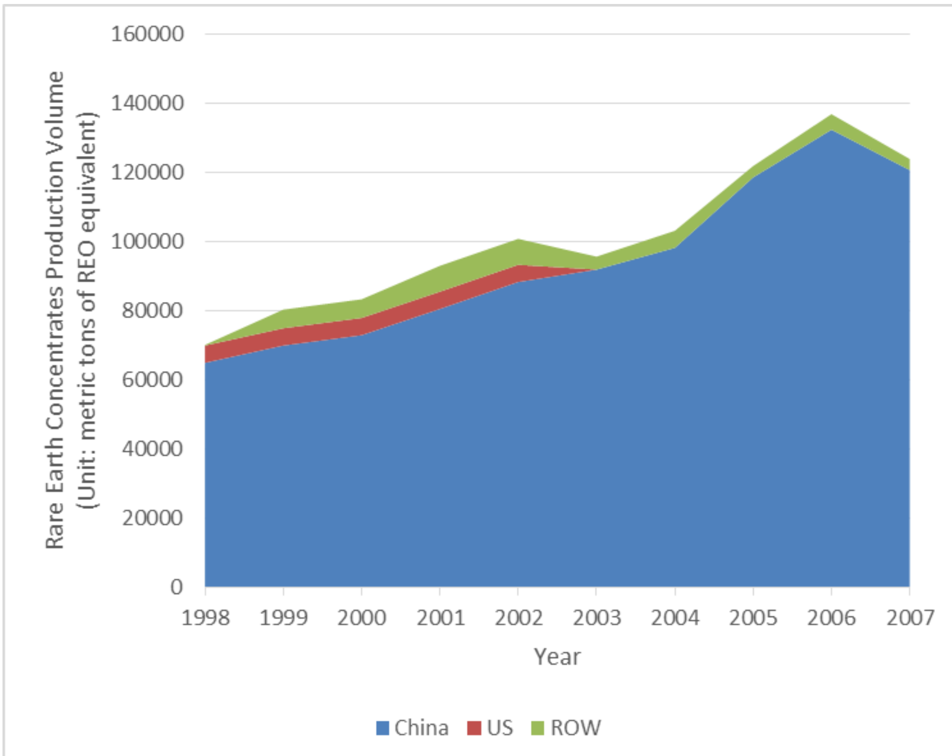

Figure 44 Production Volume of Rare Earth Concentrates by China, U.S. and the Rest of the World (ROW) in 1998-2007[271]

[271] China statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评) published by the Rare Earth Office from 1998 to 2007. U.S. rare earth concentrate production statistics are extracted from the Minerals Yearbooks published by the U.S. Geological Survey from 1998 to 2007. Rest of the World rare earth concentrate production statistics are calculated by subtracting the volume of China's production and U.S. production from total global production volume of rare earth concentrates. The total global rare earth concentrate production volume statistics are extracted from the Minerals Yearbooks published by the U.S. Geological Survey.

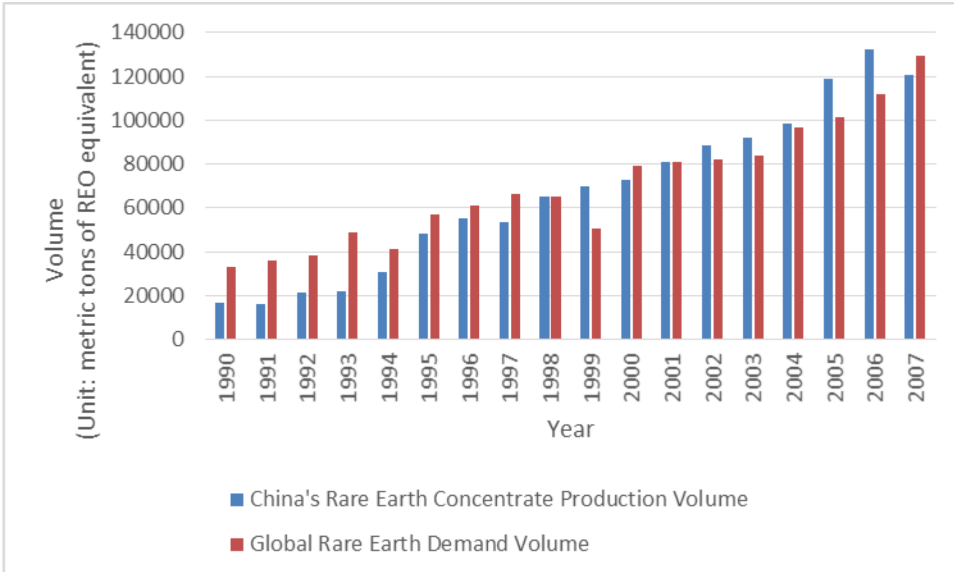

Figure 45 China's Rare Earth Concentrate Production Relative to Global Demand in 1990-2007[272]

[272] China statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评) from 1990 to 2007. Global demand statistics are extracted from the 10th Edition, 11th Edition and 12th Edition of *Rare Earths: Global Industry, Markets & Outlook* which covered data until 2007 published by Roskill, a leading international consultancy in metals research.

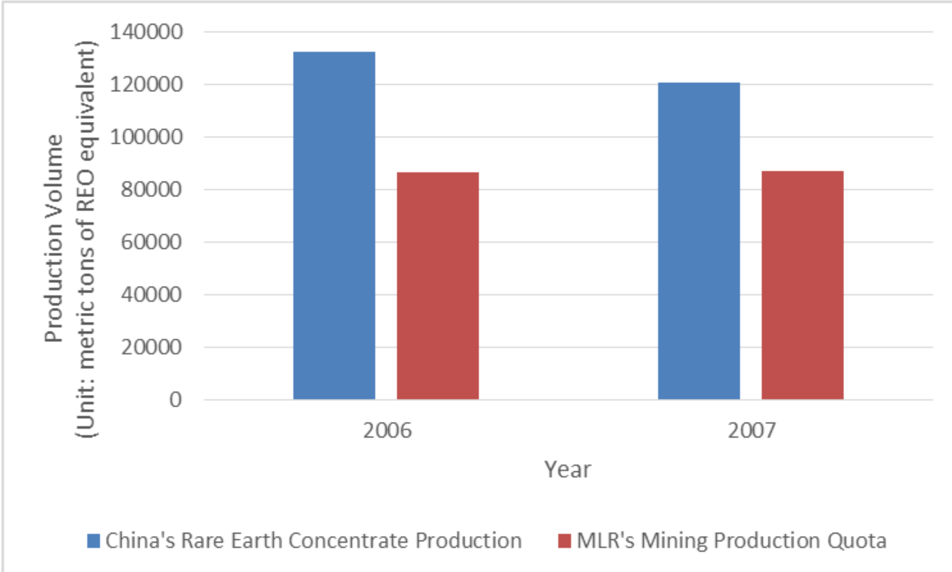

Figure 46 China's Rare Earth Concentrate Production Relative to MLR Production Quota in 2006-2007[273]

7.5.1.2 Smelting Production

Besides sustained predominance in upstream mining, China has also risen to become the world's leading producer of rare earth smelting products in this period. In terms of absolute volume, as Figure 47 shows, China's production volume of rare earth smelting products in 2007 was more than double from 1997. In terms of relative weight in global production, China's production volume was also ahead of other countries. Compared to the other major smelting producer Japan, Japan's smelting production hovered around 5000 tons (REO unit), thus China's production volume was about 10-15

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[273] Production statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评) from 2006 to 2007. MLR's Production Quota statistics are extracted from the official quota release documents on the website of the Ministry of Land and Resources. MLR started publishing mining production quota volume and allocation from 2006, after the passage of the *State Council Notice on Comprehensive Consolidation and Regulation over Mining Resource Development* in 2005.

times size of Japan's production (see Figure 48). U.S. smelting production declined significantly to almost zero production as manufacturing migrated overseas: "45 immediate downstream companies in the U.S. were closed down"[274] as a result of intense competition with Chinese counterparts. By the late 2000s Japan became the only country directly importing rare earth concentrates from China for smelting production. (Su, 2009, p. 103)

China's strong dominance in smelting production was partially due to its predominance in mining output and the state's failure to enforce production quota restrictions, leading to consistent strong supply of rare earth smelting products at low prices. It was also partially due to the foreign downstream producers (consumers of rare earth smelting products) and further downstream producers moving production facilities to China. This was particularly evident in the case of the U.S., where the majority of U.S. producers in downstream industries such as magnets, catalysts, lighting and displays, as well as further downstream industries such as automobiles, televisions and cell phones, shifted production to China or set up joint ventures with Chinese companies in this period.[275] In other words, China's sustained dominance in rare earth smelting production was accompanied with the broader trend of the migration of global manufacturing supply chains to China as China became the "world factory". On the other hand, this trend of migration of supply chain left countries like the U.S. with little production facility in both upstream mining, smelting and midstream production.

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[274] Author interview with a magnetics industry analyst in Chicago in May 2012.
[275] Author interviews with a former industry engineer of a U.S. rare earth magnet company and an executive of a U.S. energy company in Washington DC in July 2012.

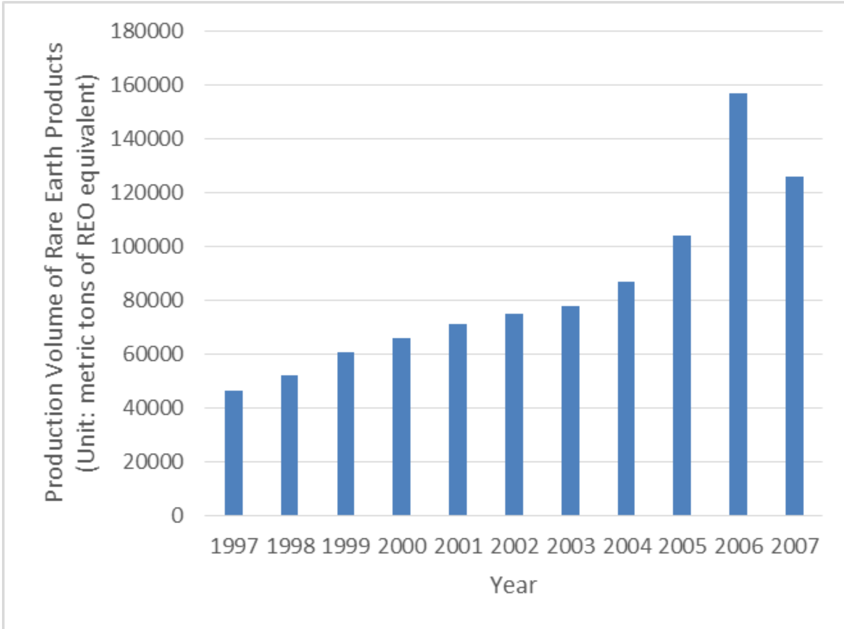

Figure 47 China's Production Volume of Rare Earth Smelting Products (1997-2007)[276]

[276] China statistics are extracted from the *China Society of Rare Earths Yearbook 2007* (中国稀土学会年鉴 2007) and the *Annual Reviews of Chinese Rare Earth Industry* (中国稀土年评) from 1997 to 2007. After 1996 rare earth permanent magnets and rare earth fluorescent materials were excluded from the category of rare earth smelting products, while they were included prior to 1996. To ensure data consistency this graph presents data from year 1997.

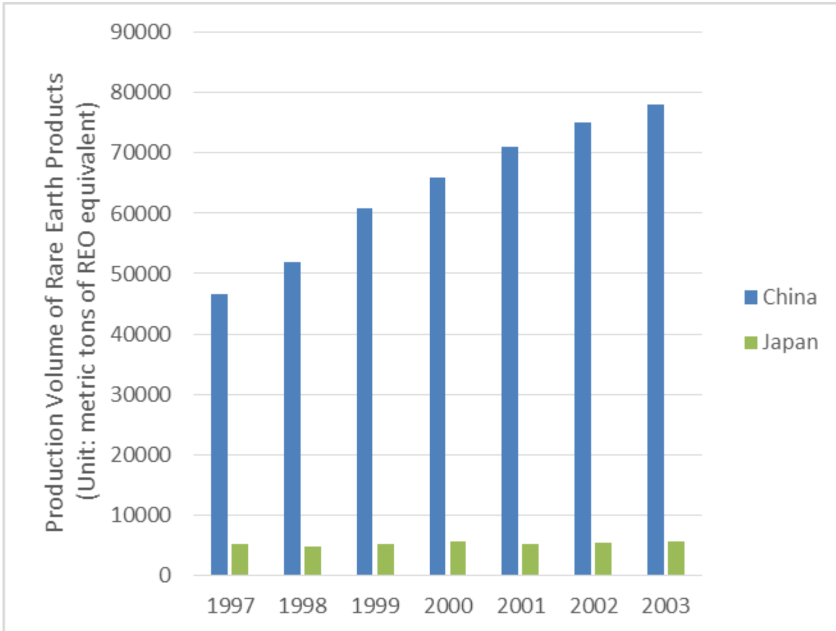

Figure 48 Production Volume of Rare Earth Smelting Products by China and Japan (1997-2003)[277]

7.5.1.3 Production of Higher-value Products

China's rare earth industry achieved substantial success in technology upgrading of industry production in this period. China's rare earth smelting production had migrated away from the model of primarily providing the most basic unrefined form of products (mixed rare earth products) in the previous two decades. In 2000, China's production of individual REE products accounted for 48.5% of total smelting production. (Rare Earth Office of the State Development Planning Commission, 2000) After 2000, the *Annual Reviews of Chinese Rare Earth Industry* stopped reporting the production volume of individual REE products, instead concentrating on reporting "rare earth new materials

[277] China statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评) from 1997 to 2003. Japan statistics are extracted from Su (2009, p.90), which was originally from the China Rare Earth Net database based on data reported by the Ministry of International Trade and Industry of Japan.

products", products that would be favored under the state's goal of industry upgrading. These include materials such as permanent magnets, phosphors, polishing powder and hydrogen-storage alloys. As Figure 49 shows, China's production of REE permanent magnets (including Sm-Co permanent magnets and NdFeB permanent magnets) grew exponentially in this ten-year period: the production volume of rare earth permanent magnets in 2008 (49300 tons) was over ten times the production volume in 1998 (4140 tons). In comparison with other countries, China also surpassed Japan to become the larger producer of sintered NdFeB permanent magnets, accounting for more than 50% of global production since 2001 (see Figure 50). Similarly as Figure 51 shows, China's production of rare earth phosphors also grew from 570 tons in 1998 to 8481 tons in 2008, an increase of over 14 times in just ten years.

In terms of consumption, China's REE consumption in 1998-2007 also showed a positive trend towards consumption by higher-value sectors. The *Annual Reviews of Chinese Rare Earth Industry* reports domestic consumption by "traditional sectors" (including metallurgy, petroleum and chemicals, glass/ceramics, agriculture, textile) and "new material sectors" (including phosphors, permanent magnets, catalytic materials, hydrogen storage materials, polishing powders). As Figure 52 shows, the consumption by new materials sectors was miniscule compared to traditional sectors prior to 1998. Yet its proportion in total domestic consumption grew rapidly in the following ten years, and in 2007 domestic REE consumption by new materials sectors for the first time was larger than domestic REE consumption by traditional sectors. These trends show that the state policies aimed at upgrading industry production was largely successful.

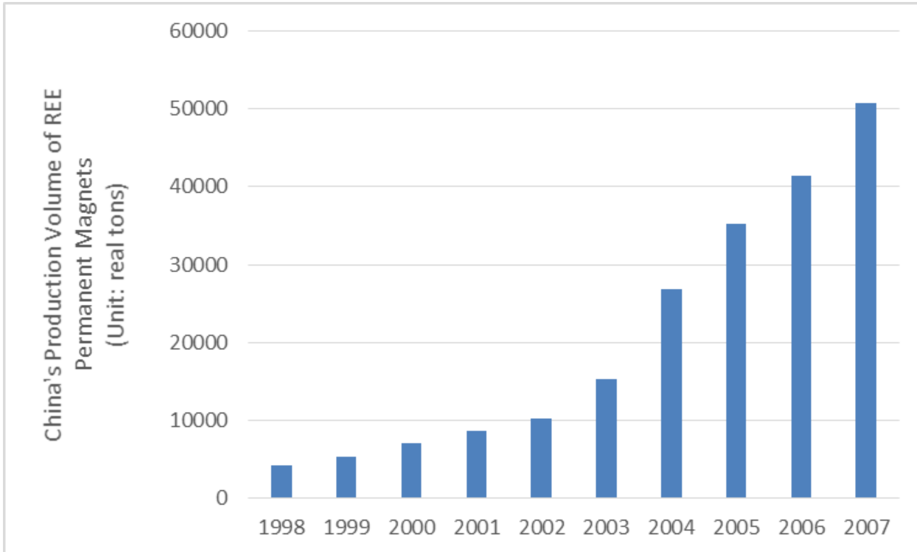

Figure 49 China's Production Volume of REE Permanent Magnets (1998-2007)[278]

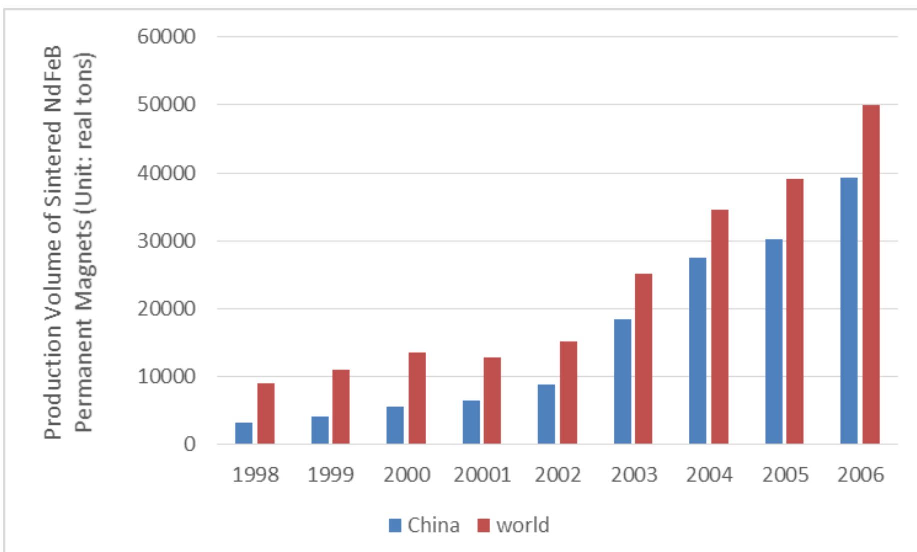

Figure 50 Chinese and Global Production Volume of Sintered NdFeB magnets (1998-2006)[279]

[278] Statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评). After 1996, the Annual Reviews of Chinese Rare Earth Industry calculates production volume of rare earth permanent magnets only in unit of real tons, not tons in REO equivalent. Thus this graph presents data in unit of real tons instead of tons in REO equivalent, different from the other graphs showing production volume.

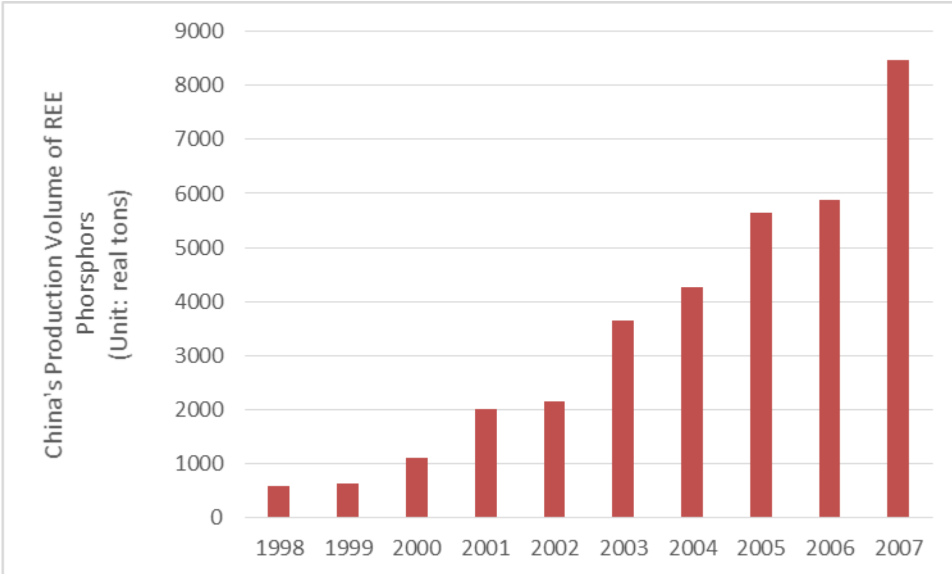

Figure 51 China's Production Volume of Rare Earth Phosphors (1998-2007)[280]

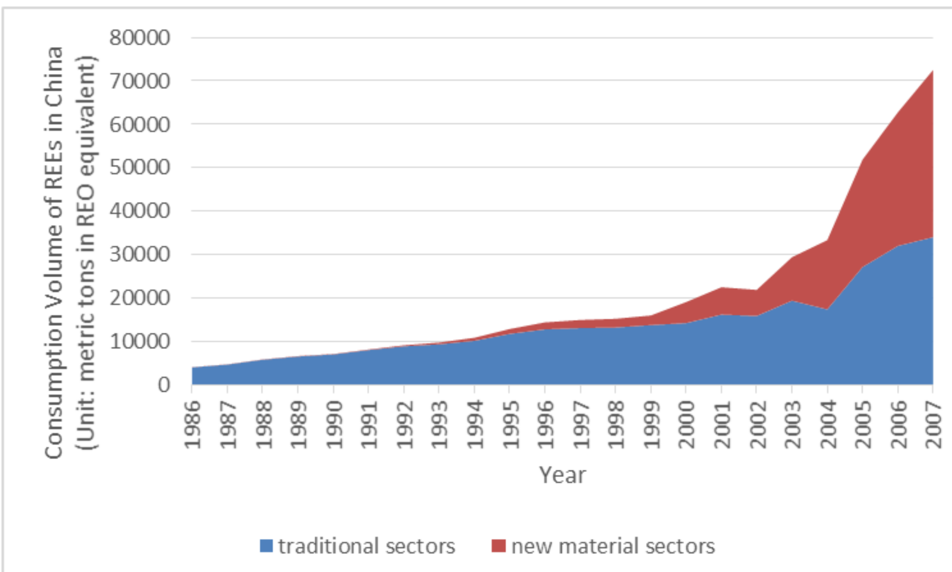

Figure 52 China's Domestic REE Consumption by Traditional and New Material Sectors (1986-2007)[281]

[279] Statistics are extracted from the China NdFeB Industry Net (钕铁硼产业网).

[280] Statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评).

7.5.1.4 Domestic Consumption Grew to Surpass Export Demand

Besides the growth of value-added production, another important trend in this period that differed from the previous two decades was the significant growth in China's domestic consumption relative to export in consuming its rare earth mining output. As Figure 53 shows, from 1998 to 2007 China's domestic REE consumption grew at a more rapid rate relative to export. In 2006, China's domestic consumption of REE surpassed export, meaning that over half of the production of REEs was consumed within the Chinese border.

This trend of domestic consumption catching up and surpassing export is not surprising. The global migration of manufacturing facilities to China meant that foreign companies who used to import from China now directly produce products using resources in the country, thus what used to be counted as export was not counted as domestic consumption. The state-imposed export tariffs on various rare earth primary products, on top of the abolishment of export rebate, also meant that it would be cheaper to produce within China rather than import from China. The rise of the disposable income of ordinary people also meant that more domestic Chinese producers were producing downstream products such as TVs, automobiles, cell phones and air conditioners, increasing the domestic consumption for rare earth products as well.

[281] Statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评).

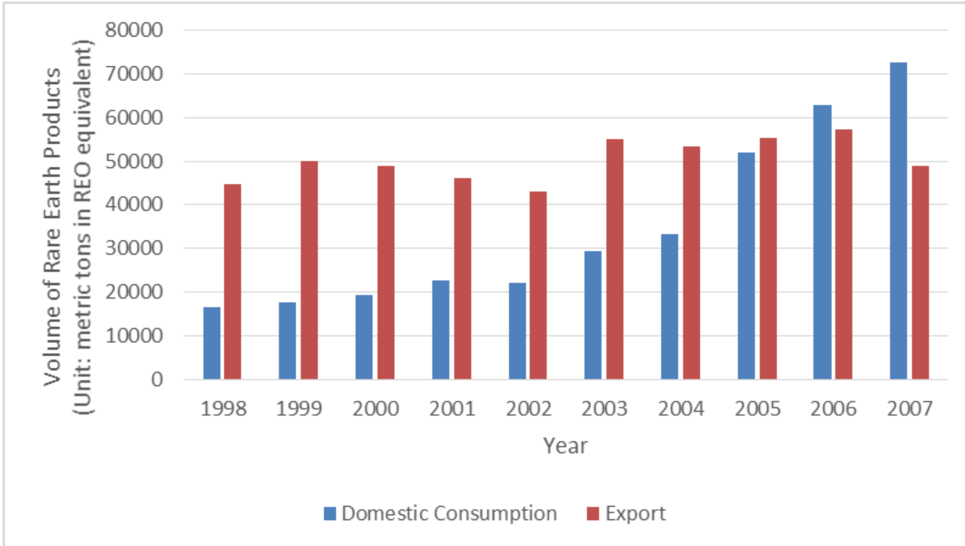

Figure 53 China's Consumption vs. Export Volume of Rare Earth Products (1998-2007)[282]

7.5.2 International Trade

7.5.2.1 Export Volume and Export Quota

As the default source of REEs to all the other countries, China's export of rare earth products, when converted into the unit of REO tons to equalize across different kinds of rare earth products, stayed relatively stable during this period as shown in Figure 53. A way to look at the levels of restrictions on export imposed by the export quota system was to compare the annual total export quota volume with the reported export volume by the end of the year. Since the export quota allocated by MOFCOM to each company was in real ton units instead of the unit of metric tons in REO equivalent, a direct comparison with export volume would need to employ the statistics of the export of rare earth products reported by the PRC General Customs in the unit of real tons. The

[282] Statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评).

result, as Figure 54 shows, is that the total volume of Chinese export subject to quota restriction was almost on par with MOFCOM's total allocated export quota in 2005-2007. The export volume reported by the Chinese customs could not have taken into account the amount of rare earth products smuggled out of China[283]. An official at the Association of Chinese Rare Earth Industry estimate that "about a third of the total real export volume was through smuggling"[284]. Therefore the actual amount of China's rare earth product export was likely to be higher than the export quota. A breakdown of the MOFCOM-imposed export quota by companies into two categories, wholly-owned Chinese domestic companies and foreign-invested joint ventures (Figure 55)[285], further shows that MOFCOM's export quota allocation ensured a good proportion (about 25%) of export quota allocated to the foreign-invested joint ventures, which often supplied the products back to their parent companies in the major importing countries including Japan, the U.S. and France. Thus despite of an export quota system in place even after China's WTO accession in 2001, Beijing's policies did not impose restrictions to the export volume to the point that the consumer companies in major importing countries might complain. The generous export quota allocation would also explain why despite of the export quota system in place for such a long time, major importing countries such as the U.S. or Japan did not file for WTO lawsuit: there was no need to do so.

[283] Smuggled export would be cheaper than export through the official customs on the international market due to no export tariff.
[284] Author interview with an official at the Association of Chinese Rare Earth Industry in Beijing in July 2013.
[285] MOFCOM allocated export quota to each company semi-annually, thus export quota volume was calculated through combining each company's allocated quota in the entire year. MOFCOM only published publicly the allocation of export quota volume by company from 2005, thus the data calculated was from 2005 to 2007.

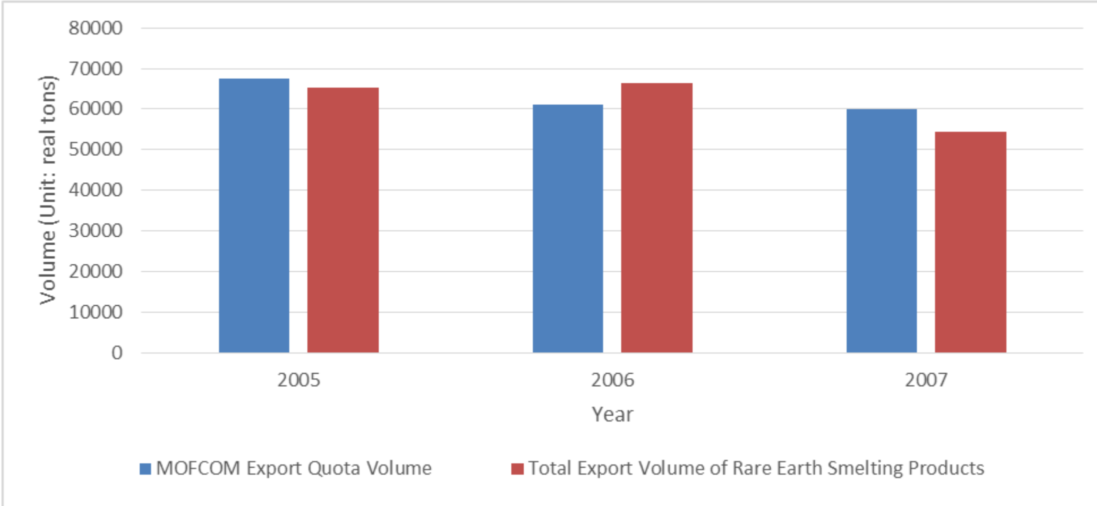

Figure 54 China's REE Export Quota in Comparison with Total Export Volume in 2005-2007[286]

[286] Export quota volume was calculated through combining the allocated quota from the semi-annual quota release document by MOFCOM. Export volume in real tons was calculated through combining the export volume of rare earth smelting products in the PRC General Customs Statistics Database. Since higher-value rare earth permanent magnets were not subject to MOFCOM export quota, only the export of rare earth smelting products were calculated.

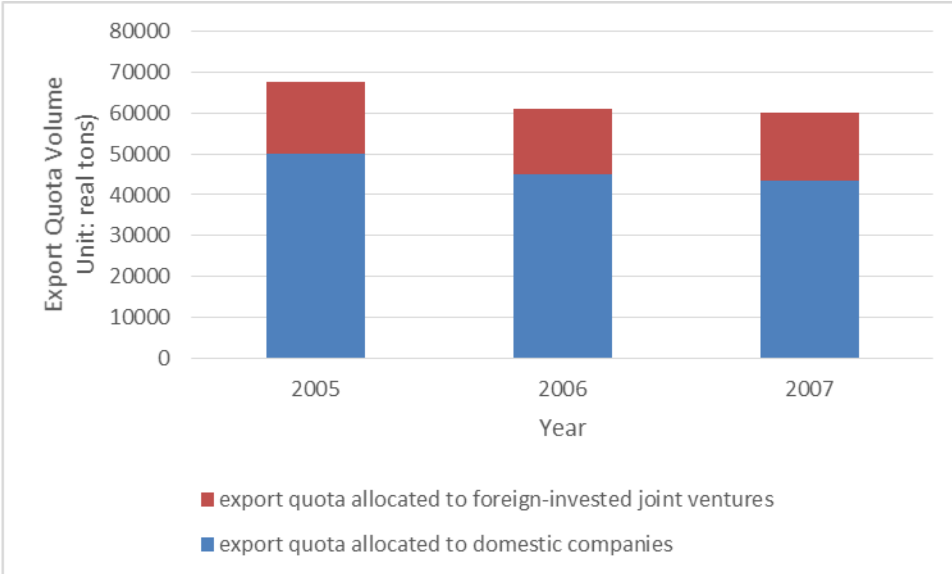

Figure 55 China's REE Export Quota Allocation to Chinese Domestic Companies and Foreign-invested Joint Ventures in 2005-2007[287]

7.5.2.2 Export of Higher-value Products

China's export in this period upgraded from basic products (rare earth concentrates, unseparated rare earth oxides, rare earth carbonate and rare earth chloride) to purified individual REE products and midstream products of higher value. After 1998, the *Annual Reviews of Chinese Rare Earth Industry* stopped reporting on the export of individual REE products, instead focusing on separate reporting of the export of permanent magnets and other different kinds of rare earth materials products. As Figure 56 shows, the value of China's rare earth product export (including both smelting products and new materials products) had an overall strong increase of almost three times in the ten year period from 1998 to 2007 when the export volume (shown in Figure 53)

[287] Export quota volume was calculated through combining the allocated quota from the semi-annual quota release document by MOFCOM.

stayed relatively flat. Figure 57 further shows that the annual export volume of rare earth permanent magnets more than doubled in this period.

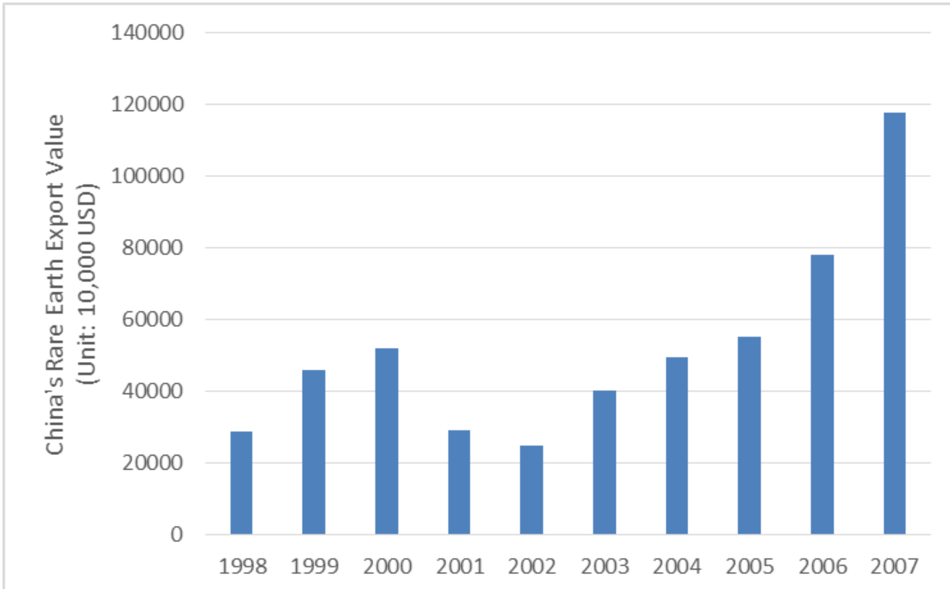

Figure 56 China's Export Value of Rare Earth Products (1998-2007)[288]

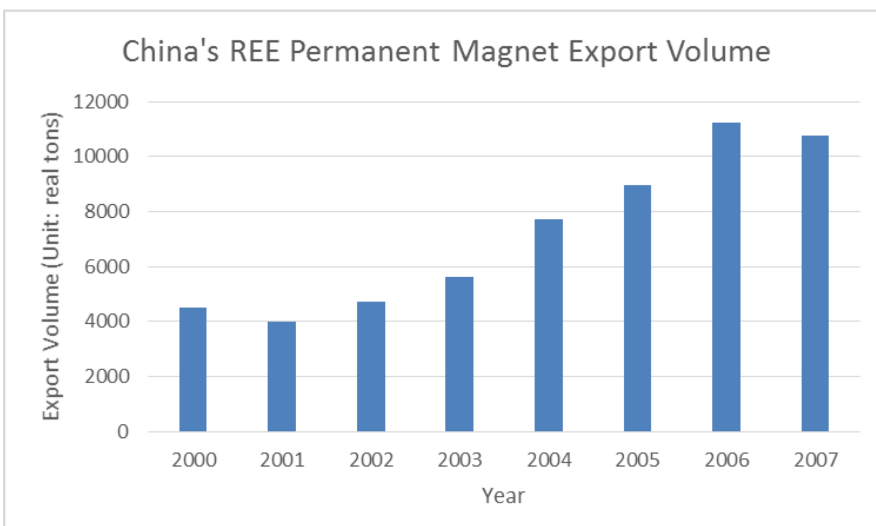

Figure 57 China's Export Volume of REE Permanent Magnets (2000-2007)[289]

[288] Statistics are extracted from the Annual Reviews of Chinese Rare Earth Industry (中国稀土年评).

7.5.3 Market Structure

Compared to the previous period, the market structure in the mining of REEs in this period showed a trend towards regional consolidation at the local provincial/prefecture level. As analyzed in the previous section, the split of the three central metal SOEs following the 1998 State Council reform resulted in the transfer of state assets and mining licenses to the local provincial/prefecture governments. Central SOEs like China Minmetals had minor control over mining licenses compared to the local SOEs and rural companies. The subsequent state attempt to reconsolidate the rare earth companies into two national state-owned conglomerate did not succeed. Thus the important players in mining were the local provincial/prefecture SOEs and semi-independent rural cooperative companies within their jurisdictions. In North China, Baotou Steel Rare Earths continued to be the quasi-monopolistic supplier. Baotou Steel's bureaucratic affiliation was transferred to the Inner Mongolia Autonomous Region Government, and the company acquired more than a dozen local companies to boost its smelting production in the region. In South China, major mining companies were provincial-level SOEs such as Guangdong Rising and Jiangxi Tungsten, prefecture-level SOEs such as Ganzhou Rare Earths and Guyun Rare Earths, and dozens of county-level rural cooperative companies. There was not one single company that controlled the mining licenses in an entire province. While consolidation was taking shape at the regional level, the management of these regional consolidated players was less decentralized than it appeared to be. There were reportedly 1197 mining sites in Ganzhou Prefecture. (Li & He, 2012) Though Ganzhou Rare Earths had control over all mining

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[289] Data is extracted from Liu (2011). Liu Yinan is the Vice President of the China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters.

licenses in the prefecture, it acted like an invoice biller for all the semi-independent mining sites.

Compared to mining where the access to market was limited by licensing and mining production quota, the market structure in the REE smelting production was much more competitive. Though the central government removed the local governments' authority to approve large-scale projects and restricted the development of new smelting projects in favor of more high-tech downstream projects, small- and median-scale smelting projects often flew under the radar. According to Su Wenqing, Former Director of the Management Commission of Baotou Rare Earth High-tech Industrial Development Zone, by 2007 there were about 130 rare earth smelting companies and about 80 rare earth metal producers in China. (Su, 2009, p. 135) Besides being larger in sheer number of companies, the market also showed an issue of chronic over-capacity: the full capacity of production of all smelting companies consistently exceeded the actual production volume of smelting products by about 30% (Su, 2009, p. 136), meaning that these companies were running at below-full-capacity level with very low profit margins. Combined with restrictions in the supply of ores due to the MLR-imposed mining quota, this resulted in an exacerbated imbalance between the supply of raw materials (ores) and the production capacity of rare earth smelting companies. This structural imbalance also prompted the smelting companies to seek out illegal sources of raw materials and in turn promoted illegal mining, as ores produced by illegal miners were priced at lower prices. Due to almost non-existent penalty to buying ores from illegal miners and the often strong protection of illegal miners provided by local government cadres, smelting companies could not care less about whether they sourced the ores from legal businesses or not.

7.5.4 Environmental and Social Impact

Though the central government made sustainable development a top priority in reregulation in this period, the environmental record of the rare earth industry in this period remained poor. The previous two decades of rapid expansion in mining and smelting left pollution legacies that were difficult and often extremely costly to treat. With no strong institutional incentive to prioritize environmental protection, local governments tended to turn a blind eye towards environmental degradation rather than devoting significant funds to treat pollution, improve infrastructure, or forcing companies to comply with environmental regulations imposed by Beijing. While the State Bureau of Environmental Protection and the local environmental bureaus conducted routine or snap environmental inspections, these inspections rarely resulted in the direct closures of polluting plants which paid fines to continue production. The prevalence of illegal mining activities tolerated by rural government cadres worsened the environment damage. Illegal miners would use rudimentary production methods with great environment damage and forgo waste treatment because new production technologies and waste discharge facilities that complied with environmental standards would incur higher production costs. (Liu, 2010)

7.5.4.1 Environmental and Social Impact in North China

In North China, rare earth mining resulted in grave damage to the local eco-system and significant casualties. The Baiyun-ebo region has dry climate with low levels of rain fall. The “tailings dam” (尾矿坝) first built by Baotou Steel to store the waste water and residue as a lake in the 1950s continued to grow rapidly in size to approximately 170 million tons of waste in this period, gradually eating up the outskirts of Baiyun-ebo region. The open air exposure combined with dry climate and low rain fall resulted in toxic dust and smog covering the entire region on windy days. (Wang, 2003) The tailings not only polluted air but also damaged the soil and the underground water. Nearby villages were dubbed by the locals as “cancer villages”, as underground water and soil were polluted by the toxins leaking from the tailings. In one village named Da La Hai, 66 people died from cancer due to exposure to toxic air and water between 1993 and 2005. Toxic water and air also led to widespread death of crops and livestock, including thousands of sheep that were starved to death because of abnormal growth of teeth. (Zhou, 2006; Li, 2010) Mining also further deprived the local water resource already threatened by the dry climate: as Baotou Steel Rare Earths became the global default supplier of LREEs, 80%-90% of the water in local rivers were used by the company and the nearby chemical plants for production. Without sufficient water for basic living, local farmers sometimes resorted to stop the companies from using water from the local rivers. (Wang & Liu, 2012) Besides environmental damages, the tailings lake was also a ticking bomb of safety hazard. The Yellow River, the primary source of drinking and industrial use water for nine provinces in North China is less than ten kilometers away from the tailings lake. As large quantities of toxic waste water and residue were dumped inside continuously, Baotou Steel had to consistently build higher tailings dams to prevent the waste from flowing out to the nearby regions on relatively lower ground. A waste water spill or a landslide would have catastrophic effects beyond the region.

7.5.4.2 Environmental and Social Impact in South China

In South China, there were similarly widespread environmental destruction in the form of soil erosion and degradation, water pollution, and the loss of ground layer of vegetation. The rapid expansion of mining through tank leaching in the previous two decades left 542 discarded mining sites totaling an area size of more than 70 square kilometers just in Ganzhou Prefecture alone. The discarded mining sites, left untreated, resulted in tailings polluting the soil, underground water and nearby farm fields. (Li & He, 2012) As tank leaching incurred large quantities of tailings (1600-3000 tons per 1 ton of REO produced) and significant environmental damage to the ground layer of vegetation (about 200 square meters of damaged ground layer per 1 ton of REO produced) to the extent that mountains were stripped of any plants or trees, the industry promoted alternative method of mining in this period. (Peng, 2005) Dump leaching (堆浸)[290] method was used at some mining sites, yet it created larger direct damage to the ground surface and vegetation and significant amount of waste residue. In-situ leaching (原地浸矿), a relatively new way of extraction, was designed to prevent the direct stripping of ground level plants and trees (seefor the in-situ leaching procedure). Compared to the two other methods, in-situ leaching resulted in much less direct damage to the ground layer of vegetation and was promoted to the mining companies by local governments. However, digging lots of wells in the mountains greatly increased the risk of landslides, a grave danger to the local community. The reagent used in in-situ leaching, ammonium sulfate

[290] Dump leaching (堆浸) is similar to tank leaching, only on a larger scale than and involving the use of large machinery. In dump leaching, the ore is taken out from the ground and then stacked on the leach pad, creating a dump of ores; the dump is then irrigated with a solution which dissolves the REEs in the ores; then the solutions are recovered for further processing.

also left residues in the mountain clay and contaminated the surface water of mountain streams and the underground water which in turn contaminated farm land and drinking water. (Liu, 2002) Thus whichever the method, the long-term damage to the local environment was significant and unavoidable, requiring expensive follow-up environment recovery procedures. The Pingyuan County Environmental Monitoring Station reported that restoring and maintaining ground vegetation coverage would require upfront cost of at least 4500 RMB/hm^2. (Chen, 2011) The environmental damage was further worsened by the prevalent illegal mining tolerated by rural government cadres. Illegal miners operating on a small scale usually used the environmentally destructive tank leaching method due to low initial costs to start production; local people described the extremely rudimentary way of doing it: strip the plants from the ground layer, dig the mud from the ground, mix the mud with chemical fertilizer and salt, and then the formed precipitate can be sold to the smelters.

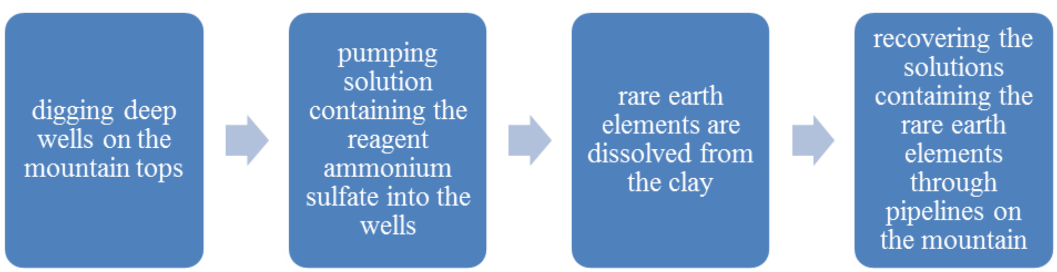

Figure 58 In-Situ Leaching Method Procedure to Extract Rare Earths from Ionic Clays in Gannan-Yuebei region

7.6 Conclusion

This chapter analyzes state reregulation in the period from 1998 to 2007. This ten year period saw China becoming a member of the WTO, expanding its marketization reform to the state-owned enterprises, privatizing the science and technology institutions, and developing its domestic innovation capability. As China became the global default supplier of REEs, the state reregulation goals in the rare earth industry changed to focus on sustainable development and industry upgrading. The state-imposed reregulation measures include mining license control and mining quota, restrictions on foreign investment, export quota and tariff on low-end products, funding and project approval priority for industry upgrading, attempted consolidation of industry into two national SOEs, and environmental treatment and inspections.

Broader political and legal institutional changes took place but did not all yield influence to the rare earth industry in the state's favor. Successive bureaucratic reforms and subsequent infighting amongst different levels of state-affiliated actors eventually resulted in weakened central bureaucratic authority over the market actors. Well-intended changes were made to improve the local cadre management system, yet did not fundamentally change its mantra of economic-growth-based promotion and its inherent incompetence in monitoring and evaluating cadre behavior. Weak legal penalty and inefficient legal prosecution procedures contributed to the lack of local enforcement of central government policies.

In retrospect, the state achieved a mix of success and failure in reregulation in this period. China sustained its leading position in global rare earth supply. With industry upgrading and global migration of manufacturing to China, Chinese domestic consumption of rare earths climbed up to rival the export. Rare earth production and export both showed significant industry upgrading from primarily low-end unprocessed products to many categories of products of higher value, though the production and export of high-tech products was still small compared to the total volume. On the other hand, Beijing's direct control over the industry and the local market actors was weak: it was not able to strictly enforce mining control, to clamp down on illegal mining and smuggling, to recentralize the mining market supply, or to curb the environmental destruction from industrial production. In terms of the impact of reregulation on the international relations, Beijing's reregulation did not result in much supply risk for downstream consumer companies in the U.S., Japan and the European Union; thus although its restrictive measures were in contrary to China's commitment to free trade, the rest of the world did not complain.

CHAPTER 8 MORE STATE REREGULATION TIGHTENING CONTROL OVER THE INDUSTRY (2008-PRESENT)

This chapter studies the current Chinese state reregulation over the rare earth industry and market since 2008. This chapter first outlines the macroeconomic environment for the industry development in this period. The Chinese state faced the dire task of lifting the economy from the impact of the global financial crisis, and Beijing implemented massive stimulus programs to boost domestic industries. The chapter then analyzes the state goals and narratives in guiding the rare earth industry development in this period, namely promoting sustainable production, satisfying domestic consumption demand, developing downstream value-added industries, and securing access to global market of value-added products. The chapter then outlines industry-specific policies in this period. The central government implemented a series of new policies to restrict and regulate mining and smelting production and export. The chapter then analyzes larger political and legal institutional changes that influenced the state's capacity to impose reregulation measures. The chapter further analyzes the outcome of state reregulation in comparison with state's goals and targets in industry production, trade, market structure and socio-environmental impact.

8.1 Macro-level Economic Change: Post-Crisis Development of Market Economy

This section summarizes the macroeconomic change in 2008-09 that influenced China's industrial policies towards the rare earth industry. A global banking crisis and the subsequent economic recession starting at the beginning of 2008 prompted Beijing to implement a massive stimulus and credit easing program to increase the Chinese domestic market consumption and government spending to rescue its slowing economy. The new State Council under the incumbent Premier Wen Jiabao also continued its efforts reforming China's under-performing SOEs and promoting ingenious innovation as the central task for China's reformed S&T institution. These macroeconomic changes spurred further changes in the goals of the state reregulation.

8.1.1 Post-Crisis Stimulus to Increase Domestic Market Growth

Although the Chinese economy has maintained double-digit growth for the previous decade, the economic growth was primarily driven by investment and export. Thus when the financial crisis and the following global economic slowdown unfolded, China saw its export growth turn negative and its foreign direct investment turn sluggish, threatening its goal to maintain high-speed growth. It was imperative for the central government to increase its domestic market demand and the businesses' access to credit to offset weak export. In November 2008, the PRC State Council under the leadership of Premier Wen Jiabao announced a major macroeconomic policy shift, a four trillion yuan ($586 billion) stimulus package and the largest in the country's history. The two-year spending plan injected funds into ten sectors, including health care, education, low-income housing, environmental protection, disaster management and reconstruction, technological innovation, transport and other infrastructure projects. The State Council also began a reform to the value-added tax system which would provide 120 million RMB tax relief to corporations. (Xinhua, 2008) Unlike countries like the U.S. where the capital for post-crisis stimulus came primarily from the central or local governments, the capital for the Chinese central government stimulus package was provided primarily by commercial banks and state-owned enterprises that were encouraged to expand more rapidly. (Barboza, 2008) Commercial banks' credit ceilings were abolished to allow for more lending to state-prioritized projects, rural companies and individuals, small- and median-scale businesses, technical innovation projects, and to provide capital for industrial mergers and acquisitions (M&As). (Xinhua, 2008)

Following the central government stimulus plan, local governments quickly sought to exploit the opportunity to apply for NDRC's approval of local investment projects, which could be directly or indirectly related to the state-prioritized sectors. As the funding allocated to the localities by the central government in the form of block grants were far from enough to fund all the approved local projects, local governments provided matching funds and obtained additional capital through central government bond revenues, special long-term bank loans from commercial banks, as well as corporate bonds issued by local government asset management platforms (地方政府融资平台). (Naughton, 2009)

The massive fiscal stimulus package has been widely credited as saving the Chinese economy from a deep recession. China's GDP growth in 2008-2013 averaged about 9% (see Figure 42), a much better record compared to other major economies hit by the global crisis. However, the policy-induced massive expansion also led to ballooning increase in local government debt, credit growth, shadow banking and surplus production capacity. (World Bank, 2015)

8.1.2 Structural Adjustment and SOE M&As in SOE Reform

The National Development and Reform Commission (NDRC) stressed the importance of "sectoral structural adjustment and SOE consolidation and mergers" (产业结构调整与重组整合) in key industries of national importance as a major task for the ongoing SOE reform in 2008. The Ministry of Industry and Information Technology (MIIT), NDRC, SASAC and MOF would work together to carry forward the process of "facilitating the transfer of state-owned assets towards important industries, key sectors and public service sectors vital to national security and economy". (PRC National Development and Reform Commission, 2008) The goal was to consolidate and expand the assets held by publicly listed companies in which the central SOEs were the major shareholders, and to develop 30-50 internationally competitive super-size corporations. (Xinhua, 2009) To promote the M&As (mergers and acquisitions) among central SOEs, the State Council provided numerous incentives, including preferential corporate tax treatment for SOEs in the M&A process, allocation of special funding for specific procedures (worker relocation and compensation, production technology upgrading, interest on bank loans) in the M&A process, preferential access to commercial bank loans and investment funds, and central-government-backed funding for innovation programs and local land rents for SOEs undergoing M&As in key industries. (PRC State Council, 2010b)

The global economic slowdown prompted the state to not only speed up its effort to consolidate the reformed shareholding SOEs into large-scale corporate groups, but also to instruct the central SOEs to acquire local SOEs and private enterprises to expand assets and market share. Weak export demand worsened the performance of many Chinese SOEs which were going through or underwent the shareholding reform not long before and were still suffering from inefficiency and low profit. In the 1st quarter of 2009, the central SOEs under the supervision of SASAC suffered a decline of 9.2% in gross operating revenue and a decline of 36% in profit, the first major decline in recent years.

Local SOEs also suffered a decline of 8.4% in gross operating revenue and a significantly worse decline of 58.1% in profit. (Xinhua, 2009) As central SOEs enjoyed the capital advantage of state-backed funding over the local SOEs and private companies, SASAC encouraged the central SOEs to partner with or acquire local SOEs/private companies and expand state assets and achieve larger economy of scale in this manner. (Economic Information & Agency, 2009) In the non-ferrous metal industries, central shareholding SOEs such as China Minmetals and China Non-ferrous Metals were encouraged to acquire local SOEs and private companies to increase the state-owned assets and have greater share of the market. (Economic Information & Agency, 2010)

8.1.3 Promoting Domestic Innovation Focusing on Strategic Emerging Industries

The Hu Jingtao/Wen Jiabao administration in their second term continued to work towards developing a high-tech-driven economy to replace the existing economic model of low-skilled low-cost export-oriented manufacturing. In the S&T institution reform, promoting domestic technological innovation of Chinese enterprises continued to be the central task. Premier Wen announced in his *Report on Chinese Government Work* in 2008 that his administration would strengthen China's S&T infrastructure and support technological innovation of enterprises, especially small and medium enterprises (SMEs). (PRC Ministry of Science and Technology, 2008) High-tech industries, such as information technology and renewable energy, were given special recognition. The central government supported innovation in high-tech industries by combining available resources across enterprises, universities, research institutes and governments to provide technical service (such as testing service, information service, R&D service, technology transfer service and training) to enterprises. (PRC Ministry of Science and Technology, 2008)

In October 2010 the state further identified seven "strategic emerging industries" (SEI, 战略性新兴产业) that would receive targeted state support. The goal was to support these nascent industries so that they would grow to account for 8% of GDP by 2015 and 15% of GDP by 2020. In *Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries*, the State Council identified seven SEIs, including energy efficient and environmental technologies, next generation information technologies, biotechnology, high-end equipment manufacturing, renewable energy, new materials and new-energy vehicles. The State Council again stressed that R&D and indigenous innovation would be the core drivers of SEI development. (PRC State Council, 2010c) Following the State Council decision, most provincial and prefectural governments implemented their own policies and funding support designed to promote the development of local enterprises in the SEIs in their jurisdictions. (US-China Business Council, 2013)

8.2 Goals and Narratives of the State

This section analyzes the changing goals of state in the post-2008 current reregulation of the rare earth industry. State reregulation in the previous decade led to mixed results, prompting the state to adjust its industrial policy. The 2008 global financial crisis and Beijing's post-crisis programs also brought new macroeconomic changes to the Chinese economy, influencing the state's goals in reregulating the rare earth industry.

8.2.1 Goals of State Reregulation: Sustainable Production and Environmental Protection

One consistent concern that has not changed in the state reregulation is the fact that the REEs are non-renewable minerals; thus once the reserves are depleted, there would be no more deposits to mine from. With greater technology innovation since the 1980s, REEs have been found to be useful in a variety of both civilian and military technologies. Thus it would be in the interest of the Chinese state to ensure the long-term sustainability of China's rare earth production so that it would meet the needs for the minerals in the future.

The State Council released the landmark *Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earth Industry*, an industrial governance guideline in 2011. It is only the third document that has been directly released by the State Council over an industry in the non-ferrous metals industries to date (the first two being on gold in the 1950s and on coal in the 1960s). It has thus generated significant momentum in corresponding new policy campaigns at the ministerial level as well as new policies at the local provincial government level[291]. In the document, the State Council acknowledged that "rare earths are an important strategic non-renewable resource, and are increasingly widely used in such fields as new energy, new materials, energy saving, environmental protection, aeronautics, astronautics, electronics and information technology. Effective protection and rational utilization of rare earth resources are of great significance in protecting environment, accelerating the fostering and development of strategic emerging industries, transforming and upgrading

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[291] Author interview with a senior manager at a state-owned mining enterprise in Guangzhou, Guangdong Province in June 2013.

traditional industries and promoting the sustainable and healthy development of the rare earth industry." (PRC State Council, 2011b)

As the previous chapter analyzes, in the previous decade from 1998 to 2007, due to China's production capacity expansion and the U.S. exit from production, China became the default REE supplier to the entire world while its share of the global REE reserves remained less than 50%. The mining licensing requirements and quota restrictions imposed by the MLR since the early 2000s were ineffective in controlling the volume of production. In the views of many Chinese experts who were long involved in industry development since the early years of expansion, the long-term consequence for China was exhausting its resources at an alarming rate[292]. In the words of Xu Guangxian, the renowned "Father of the Chinese Rare Earth Industry", "I fear that after twenty to thirty years, China as a country will only have little rare earth resources left." (Hao, 2013) Thus curbing production volume through implementing and enforcing stronger state regulations would be the logical choice.

Compounding this fear of the long-term unsustainability of production was the low market pricing and low profit that plagued the rare earth industry in the years between 2002 and 2007. A widely held belief among experts was that the Chinese rare earth industry needed to rein back its production to prop up the unfairly low prices and achieve sustainable profit margins[293]. As the previous chapter analyzes, the chronic over capacity of China's rare earth smelting production relative to both the mining quota and the market demand meant that most rare earth companies would be running on razor-thin

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[292] Author interview with a senior officer at the Chinese Society of Rare Earths in Beijing in July 2013.

[293] Author interview with a senior officer at the Chinese Society of Rare Earths in Beijing in May 2013.

profit margins. Illegal mining and smuggling businesses, without the burdens (such as tariffs, quota compliance, environmental treatment or fines) that legal companies had to shoulder, further dragged down the market price. China's monopoly in market share in the early 2000s did not result in price increase, but exceedingly low prices across the board. The price of major rare earth oxide products almost all declined to historically low levels after 2002 (see Figure 59, Figure 60, Figure 61, Figure 62, Figure 63, Figure 64[294]). According to statistics provided by Su Wenqing, then Director of the Management Committee of Baotou High-tech Zone, the rare earth companies registered in Baotou Prefecture had altogether a net profit/sales revenue ratio of merely 2.85%, 1.60%, 4.19% and 4.98% in 2004, 2005, 2006 and 2007. (Su, 2009, p. 196) This low pricing and profit lent stronger support to the experts' consensus that Chinese companies were producing too much, creating a "buyer's market" instead of a "seller's market". As an REE-rich country China risked "losing the valuable resources through underselling"[295]. The low pricing also prompted some legit rare earth companies to complain to Beijing that the state was not acting strong enough to enforce its regulations in all local regions and eradicate black markets, and stronger state regulations would help them gain a leveled playing field and get better profits[296].

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[294] Pricing data is extracted from China Rare Earth Net (http://www.cre.net).

[295] Author interview with a senior researcher at the Chinese Academy of Social Sciences in Beijing in February 2013.

[296] Author interview with a senior official of the Association of China Rare Earth Industry in Beijing in July 2013.

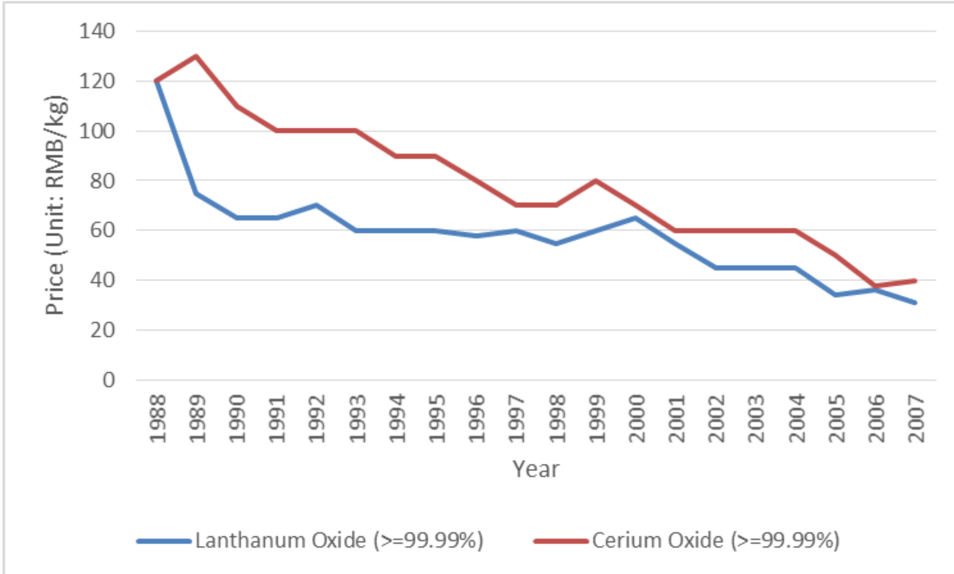

Figure 59 Chinese Market Average Price of Lanthanum Oxide and Cerium Oxide in 1988-2007

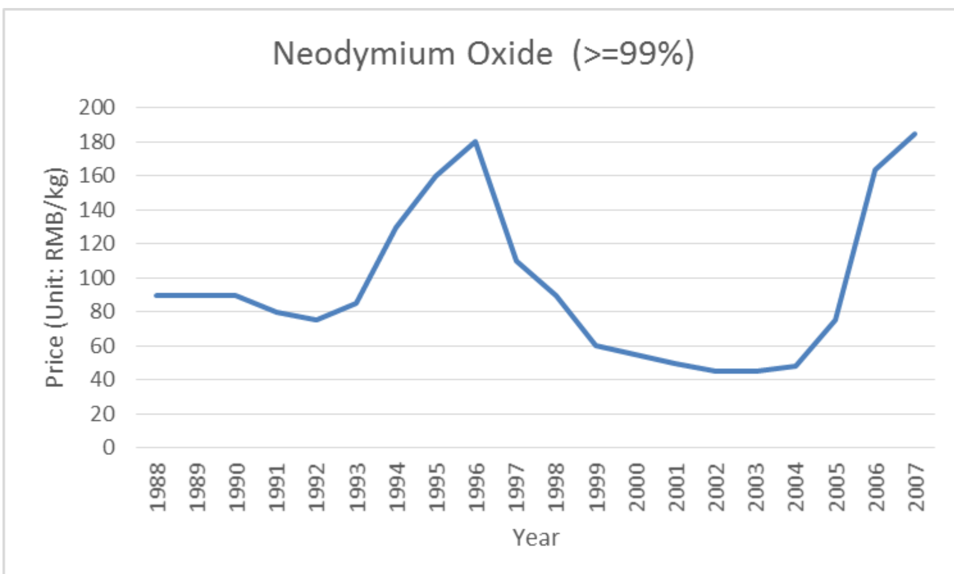

Figure 60 Chinese Market Average Price of Neodymium Oxide in 1988-2007

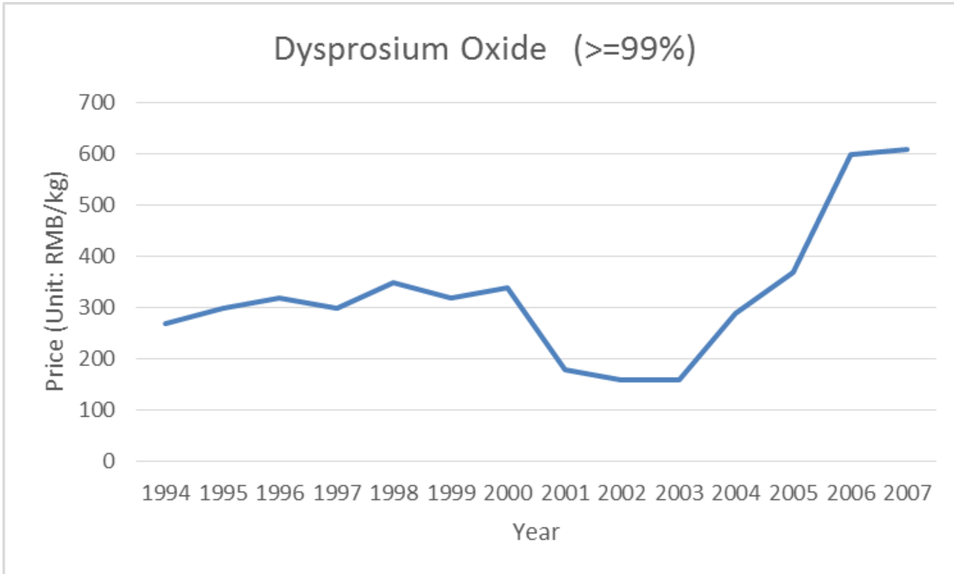

Figure 61 Chinese Market Average Price of Dysprosium Oxide in 1994-2007

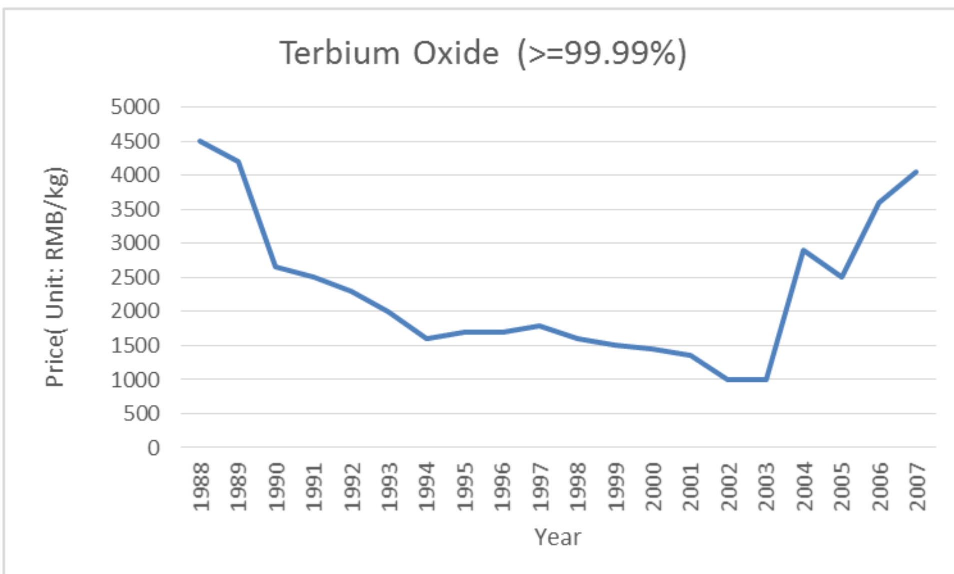

Figure 62 Chinese Market Average Price of Terbium Oxide in 1988-2007

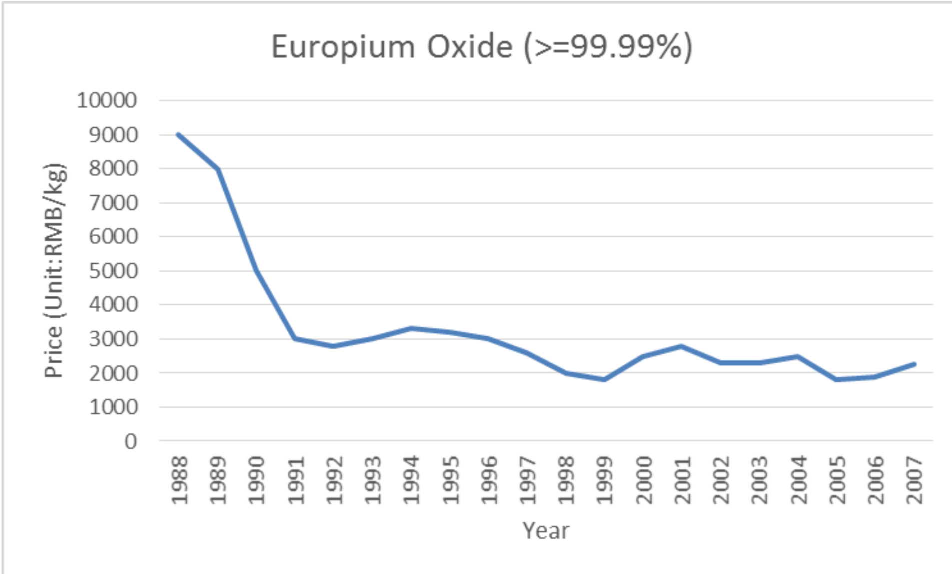

Figure 63 Chinese Market Average Price of Europium Oxide in 1988-2007

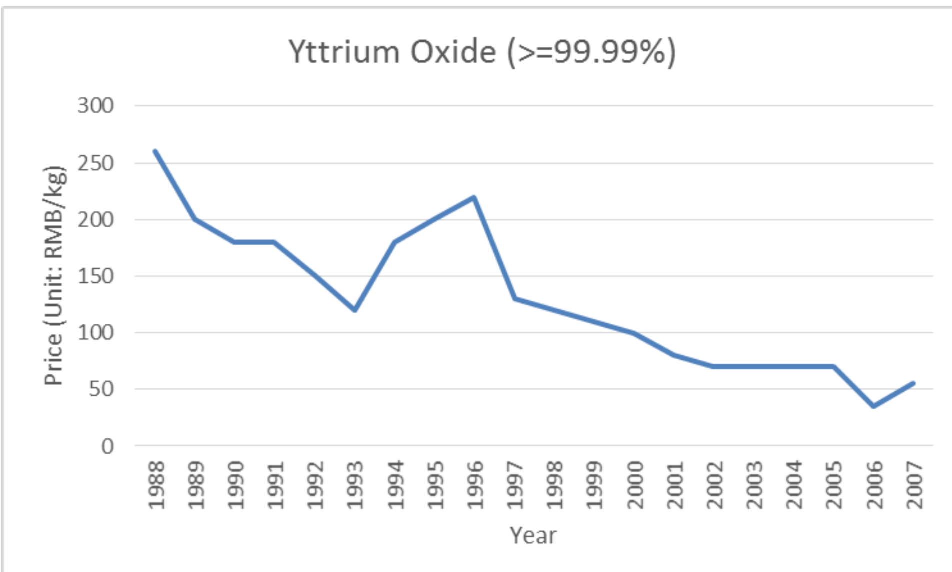

Figure 64 Chinese Market Average Price of Yttrium Oxide in 1988-2007

Sustainable production not only means that the production needs to meet both the current and the future demand; it also includes the notion that the production needs to be environmentally friendly. As shown in the previous chapters, rare earth mining and smelting in China are energy-intensive, water-intensive processes that create environmental waste and long-term ecological damage. In both North China and South China, production in the 1970s to late 1990s was conducted using backward environmentally-destructive technologies, leaving significant environmental damage that would take years and huge funding for the producers and the local authorities to treat. Recent changes in mining technologies, such as the transition from dump leaching to in-situ leaching, led to improving environmental conditions, but also generated additional environmental concerns. Since environmental protection is both a historical and an ongoing difficult issue to tackle, curbing environmental damage has continued to be a primary concern of the state in the current post-2008 reregulation.

The necessity and the urgency of the state to enforce environmental change was reinforced by its past policy failure in regulating the environmental impact of production. Despite of Beijing's upholding of "sustainable development" as a primary development goal in the previous decade, it failed to achieve much progress in curbing the environmental damage associated with rare earth production. Local government leaders had little institutional incentives and often also not enough financial resource to treat the existing heavily-polluted areas. Local government cadres were also inclined to turn a blind eye towards businesses not in compliance with state environmental guidelines, but kept up local employment and generated tax revenues for the local government. The rare earth companies that were running on low or negative profit margins would rather pay small fines for environmental violation or install temporary fixes (relocating local residents, changing waste dump sites), instead of devoting large amount of funding to environmental restoration projects. Furthermore, the prevalent illegal businesses operating outside of state regulations would naturally evade any pollution treatment and make the environment damage worse. Because “environmental cost was not added into the production cost”, all these problems that worsened environmental degradation also indirectly contributed to the over capacity of production and the low market prices, thereby “punishing the do-good companies”[297]. To avoid the industry going down a “race to the bottom”, the state would have to enforce stronger environmental regulations.

8.2.2 Goals of State Reregulation: Technology Upgrading to Fulfill Domestic Demand

Apart from the goal of sustainable production and environmental protection, another recurring goal driving the state to implement the post-2008 reregulation was to promote rare earth industry upgrading and to facilitate the development of its downstream industries. The Hu/Wen administration’s unwavering campaign since 2004 to develop China’s “ingenious innovation” continued to feature prominently in its policy towards the rare earth industry.

The post-crisis 4 billion RMB stimulus package enacted by Beijing as well as the follow-up packages enacted by many local governments in 2008-09 prompted greater projected demand for REE-enabled applications, thus making it necessary for the rare earth industry to expand its value-added production. The rapid expansion of infrastructure development projects and technology upgrading projects in China following the 2008 Financial Crisis created higher market demand for REE-enabled applications from downstream industries. It also created more resources for companies to fund rare earth applications projects. By 2010 China’s production of major rare earth applications,

[297] Author interview with a senior manager of a state-owned rare earth smelting company in Baotou, Inner Mongolia in August 2013.

including permanent magnets, phosphors, polishing powders, hydrogen storage alloys and catalytic purifiers had grown by 135%, 66%, 153%, 37% and 81% respectively compared to 2005. The 12^{th} Five-Year Technology Plan (2012-2016) set a goal of $300 billion in clean energy investments. MIIT projected that in the next five years between 2011 and 2015, the clean energy industry alone would consume at least 40,000 tons of rare earth permanent magnets, and the lighting industry would consume at least 50,000 tons of rare earth phosphors. (PRC MIIT, 2012a; PRC MIIT, 2012b) Thus in order to fulfill the state's ambitious plans of building "ingenious innovation" and a "national innovation system", the rare earth industry would need to go through further production technology upgrading to provide more and better value-added products to fulfill the projected downstream demand.

Although China was the global default supplier and the largest smelter of REEs, its portion of high-end production was still not enough to meet the demand from its domestic downstream industries. As the previous chapter demonstrates, by 2007 the entire upstream of the global rare earth production chain had migrated to China. Many foreign producers in the downstream industries such as automobiles, cell phones and lighting also chose to relocate part of their production to China. Beijing's measures promoting technology upgrading also led to significant domestic expansion in the production of REE-enabled applications. As a result, apart from being the largest supplier of REEs, China became the world's largest consumer of rare earth metals and the largest producer of major REE-enabled applications in volume. Yet the pace of technology upgrading was not enough: Chinese domestic companies in the downstream industries still needed to import high-end REE-enabled applications, such as high-end permanent magnets from other countries such as Japan.

8.2.3 Goals of State Reregulation: Resource Advantage Facilitating Downstream SEI Development

China's lack of high-tech production grew more acute under Beijing's new campaign of building "strategic emerging industries" (SEIs) in 2010. As Chapter 4 demonstrates, China was then still lagging far behind other countries such as the U.S. and Japan in the development of such crucial downstream SEIs as renewable energy, new materials and new-energy vehicles. Thus even if the Chinese rare earth industry could produce more and better high-end REE-enabled applications, there would be not enough domestic consumers. In order to catch up in production in both high-end REE-enabled materials and in downstream industries, Chinese producers needed foreign technologies.

Though not stated explicitly, both Beijing and the local governments in the rare earth production regions hoped that policy changes would prompt more foreign firms to partner with domestic downstream firms to develop high-tech products and boost the technology upgrading of the rare earth production chain in China. Beijing's tone was more of a nuanced frustration of "being powerless against foreign monopoly on technology despite our nameplate monopoly in resource production"[298]. Many Chinese rare earth experts felt that "the full economic benefit of China's rare earth resource endowment would only be realized through high-value-added production, which largely remains in the control of foreign firms; it is unfair for foreign firms to complain about Beijing regulating its rare earth production and export, as Chinese producers kept

[298] Author interview with a senior officer at the Chinese Society of Rare Earths in Beijing in May 2013.

supplying advanced countries with rare earth products at very cheap prices while leaving us the huge environmental pollution that other countries did not bear, and China still needed to import downstream products at far more expensive prices"[299]. Local governments, more focused on their own local jurisdictions instead of the national level, expressed similar frustrations of "providing cheap resources and materials products that ultimately would have to be sold to companies elsewhere"[300]. In a press conference in 2009, Vice Chairman of the Inner Mongolia Autonomous Region plainly said of the intent to use resources to attract the relocation of foreign firms into the local industrial parks, "We are not taking the short-term view of just trying to prop up prices. Imposing controls and reducing exports aim to attract more factories using rare earth metals from home and abroad to Inner Mongolia". (Li & Liu, 2009)

8.2.4 Goals of State Reregulation: Breaking the Barrier to International Markets

Beijing's strengthened reregulation also came at a time of growing conflicts of interests between China and Japan. With U.S. companies either exiting PM production or migrating production to China in the early 2000s, Japan came to occupy nearly 80% of global high-end permanent magnet market share as shown in Chapter 4. Thus unlike the U.S. and the European companies which were mainly concentrated in downstream industries, Japanese companies were both direct consumers and also direct competitors to Chinese companies. Beijing and Tokyo had maintained institutional communications over their respective rare earth industrial policies since the late 1980s. In 1987 the P.R.C. central government and the Japanese government established the Sino-Japan Rare Earth

[299] Author interview with an academician at the Chinese Academy of Sciences specializing in rare earth industry research in Beijing in June 2013.
[300] Author interview with a senior researcher at MOFCOM in Beijing in January 2013.

Communication Framework, aimed at strengthening the Sino-Japan relationship in the rare earth global production chain. Through this framework, both countries subsequently held the annual Sino-Japan Rare Earth Communication Conference around October of each year, with locations alternating between China and Japan [301]. From 1988 to 1998, the conference included participants from the government, the private sector and research institutions. From 1998 the conference was changed to be a high-level inter-governmental dialogue involving only government-related participants. The Japanese government delegation was led by the Office of Mining under the Department of Energy and Resources at MITI (later reorganized into METI in 2001) and also included representatives from JOGMEC (Japan Oil, Gas and Metals National Corporation), industry associations (such as New Metals Industry Association) and research institutes (such as Japan Metal Economy Research Institute). The Chinese government delegation was led by the State Planning Commission (1998-2002) and later the NDRC (2003-2009) and also included representatives from other central government ministries and key SOEs in rare earth mining and magnets production (such as Baotou Steel, Jiangxi Southern Rare Earths, Guangzhou Zhujiang Rare Earths[302]). The annual meeting agenda primarily consisted of briefings from both sides over a range of issues in the previous year[303]. The briefing topics included production, sales, trade conditions, national and international market demand, as well as REE-enabled technology applications. The participants from

[301]The meeting is called 日中レアアース交流会議 in Japanese, 中日稀土交流会议 in Chinese.
[302] Guangzhou Zhujiang Rare Earths is a major rare earth smelting plant and a subsidiary of Guangdong Rising Non-ferrous Metals.
[303] The past conference agendas can be obtained from the METI website (mric.jogmec.go.jp/public/report/).

China and Japan exchanged information and engaged in discussions and negotiations about future market trends and industrial policies.

However conflicts of interests grew and by 2008 Chinese participants felt it was difficult to draw consensus and maintain negotiation on friendly terms and make more accommodating policies from Beijing[304]. A Chinese participant recalled that by the late 2000s, the communication from both sides grew more tit-for-tat in the way of "if you do this, I will respond with this". At one meeting with Chinese government officials, a middle-ranked Japanese government official threatened to block other Japanese export if Japan needed to reduce its rare earth import from China, leading to strong suspicion from the Chinese participants that policy coordination on the inter-state level would be going nowhere[305]. The last Sino-Japan Rare Earth Communication Conference took place in 2009 and did not resume ever since. Besides the growing distrust and lack of consensus between Beijing and Tokyo, bureaucratic changes within the Chinese State Council also contributed to the halt of such institutionalized interstate collaboration. The 2008 State Council reform split the NDRC's responsibilities in industrial policy implementation into specialized agencies in several ministries (for the rare earth industry, this included the MLR, the MEP and the newly formed MIIT), thus there was no longer a "supra-ministry

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[304] Author interview with a well-known rare earth industry expert and a long-term participant of the Sino-Japan Rare Earth Communication Conference in Beijing in June 2013.

[305] Author interview with a well-known rare earth industry expert and a long-term participant of the Sino-Japan Rare Earth Communication Conference in June 2013. It should be noted that while the full context of this message from the Japanese government official is unclear (whether it is a credible threat or a tactical message, and whether there were similar threats before from either side), this incident and Beijing's reactions showed the growing antagonism in Sino-Japan negotiations.

agency" like the former NDRC that could send out officials to lead international negotiations on behalf of the entire State Council[306].

A major point of contention in Beijing's perspective concerns the extent of patent validity of the REE-enabled sintered permanent magnets technology. Hitachi Metals owns over 600 patents worldwide relating to sintered rare earth magnets, including over 100 patents in the U.S. alone. Hitachi's U.S. Patent 5,645,651 (known as the "651" patent) filed in 1983 in most major international markets is the basic patent covering the composition and key properties of matter for sintered NdFeB magnets. As Chapter 5 analyzes, Hitachi's patent filing was rejected by the State Intellectual Property Office in 1985, thus the patent exclusion does not apply to the Chinese market. Companies not licensed by Hitachi/SSMC have still been able to produce and sell sintered NdFeB magnets in China, but not abroad. As China gradually became the world's largest producer of NdFeB magnets in volume in the 2000s, the patent exclusions felt like a stranglehold on Chinese companies. Chinese companies anticipated that under the most common policy of 20-year expiration, the "651" patent would expire in 2003. However, Hitachi was able to extend the validity of the "651" patent covering the right to manufacturer and sell sintered NdFeB magnets in the U.S., Japan and the European Union until July 2014[307]. Hitachi has also sought to extend the exclusive intellectual

[306] Author interview with a well-known rare earth industry expert and a long-term participant of the Sino-Japan Rare Earth Communication Conference in Beijing in June 2013.

[307] Patent expiration and extension policy varies from country to country. Article 33 of the TRIPs Agreement of the WTO states that "The term of protection available [for patents] shall not end before the expiration of a period of twenty years counted from the filing date." Most countries follow the expiration policy of 20 years from the earliest filing date of the application on which the patent was granted, yet many countries such as the U.S. and Japan also have clauses allowing for extension of the expiration date.

property right over NdFeB magnet production through the "processing" patents[308] in its patent portfolio. In other words, even as the "651" composition patent expires, Hitachi argues that it would still be able to claim patent protection until the last "process patent" expires around 2029. According to the most recent information (see Table 6), by 2014 Hitachi Metals has licensed only 13 companies to manufacture and sell sintered NdFeB magnets under Hitachi Metals' patents worldwide.

[308] Hitachi has also filed "process patents" that detail the process essential to the production of sintered NdFeB magnets.

Table 6 Hitachi-licensed NdFeB Permanent Magnet Producers

Country	Producers
Japan	Hitachi; Shin-Etsu Chemical; TDK Corporation
U.S.	Hitachi U.S.
Europe	Magnetfabrik Schramberg GmbH; Neorem Magnets Oy; Vacuumschmelze GmbH
China	Advanced Technology & Materials (AT&M); Anhui Earth Panda Advanced Magnetic Material Company; Beijing Jingci Magnetism Tech. (BJMT); Ningbo Yunsheng; Ningbo Jinji Strong Magnetic Material Company; Thinova Magnets; Yantai Zhenghai Magnetic Material Company; Zhongke San Huan High-tech Company;

This exclusive and extended protection of a technology that is over thirty years old and might extend for another ten to fifteen years has long been disputed by Chinese companies, and it has become a major concern for Chinese participants in Sino-Japan Rare Earth Communication Conferences. Sun Baoyu, president of Shenyang General Magnetic Co and head of a Chinese magnet producer coalition remarked that “what

Hitachi Metals has done is to set up trade barriers" that ban most Chinese magnet producers from selling abroad. (Du, 2013) Producing companies had to choose between paying expensive licensing or contracting fees to access key foreign markets, or sell only to limited regions where the patents expired after 20 years with no extensions. Consumer companies of permanent magnets had limited choices of Hitachi-licensed suppliers. If they just purchased unlicensed magnetic materials as raw materials and then sold final products abroad, it would make themselves the prime targets of IPR infringement lawsuits[309]. The fiscal stimulus plans implemented by government around the world after the 2008 Financial Crisis prompted the ramping up of production in new high-tech industries such as new-energy vehicles and renewable energy. This created short-term jumps in demand for permanent magnets. Yet due to patent exclusions, China's cheaper supply of permanent magnets could not access these emerging high-tech consumers (such as HEV/EV producers, wind turbine producers) in Japan, Europe and the U.S. There were more than 200 Chinese firms producing NdFeB magnets; only five Chinese companies became Hitachi licensees eligible to produce magnets for the overseas market by 2010. About a quarter of the Chinese producers were able to send their products to be sold abroad through contracting with the licensee firms. (Du, 2013)

8.3 Industry-Specific Regulatory and Policy Changes

[309] It's not unusual for patent holders to sue the downstream and down-downstream purchasers of unlicensed products for IPR infringement. Hitachi/SSMC sued two telephone making companies in 2000 for buying magnetic materials from producers not licensed by Hitachi/SSMC and distributing the final products to the U.S. market. Similarly, Magnequench sued ten manufacturing companies in the New York state court and the Indiana State Court in 2001 for buying CD-ROM and DVD-ROM made using magnetic materials made by unlicensed Chinese and Thai producers and distributing the final products to the U.S. market. (Shenzhen Business Daily, 2001)

Since 2008 the Chinese central government has strengthened its reregulation policy campaigns over the rare earth industry. The central government has both introduced new rules and initiatives and revised the pre-existing policies. This section covers in detail the state reregulation policies in production, market entry, export, industry upgrading, industry restructuring, anti-smuggling and pollution control since 2008.

8.3.1 Regulatory and Policy Changes on Domestic Production

8.3.1.1 Regulatory and Policy Changes on Mining Production

In terms of mining production control, the Ministry of Land and Resources (MLR) has continued to issue rare earth mining quota (i.e. the maximum amount allowed to mine) to each province, named as "guideline for mining rare earth ores" (稀土开采指标). Since 2012 MLR has switched from issuing yearly mining quota to two batches of half-year quotas allowing for adjustments later in the year. The mining quota allocated to each province would be managed by the provincial Bureaus of Land and Resources and allocated to each rare earth mining company/site. As shown in Figure 65, the post-2008 annual quota volume remained stable compared to pre-2008 quota volume, and there was in fact a greater allocation of quota to the mining of higher-valued HREEs.

MLR has also continued the halt of licensing for new mining projects and has increased control on the existing local rare earth mines. (PRC Ministry of Land and Resources, 2014) In May 2010 MLR issued a nation-wide inspection of rare earth mining firms, with emphasis on environmental standards and production quota compliance and crackdown on illegal mining and smuggling activities. (PRC Ministry of Land and Resources, 2010) In January 2011 MLR issued an announcement that the Ganzhou

Prefecture in Jiangxi Province would become the first local rare earth mining district under national planning (国家规划矿区). (PRC Ministry of Land and Resources, 2011) In 2012, MLR announced that it had conducted a round of inspection of rare earth mines and consolidation of mining licenses, resulting in a reduction of the total number of mining licenses[310] (采矿证) from 113 to 67. （PRC Ministry of Land and Resources, 2012）

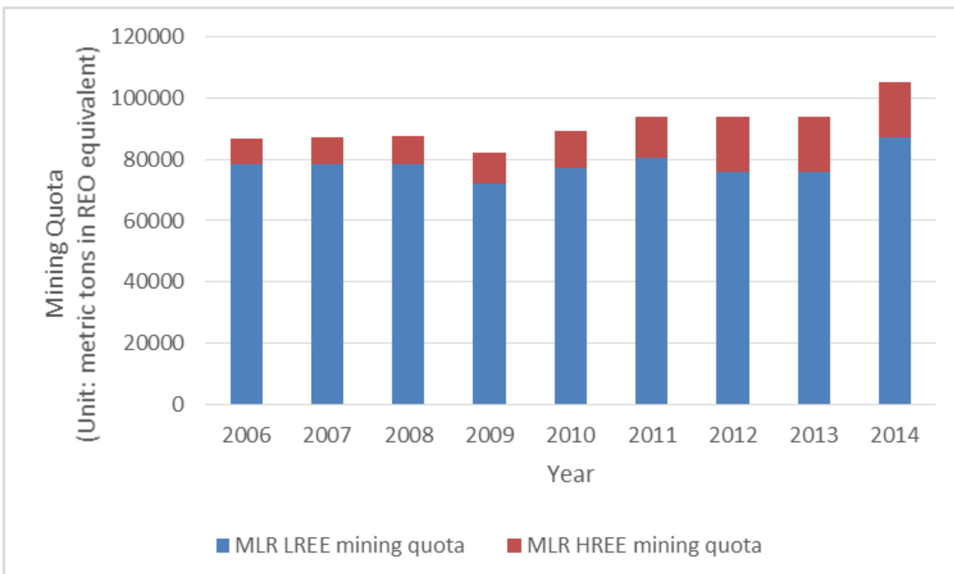

Figure 65 China's Rare Earth Mining Quota (2008-2014)[311]

Besides volume control of rare earth mining, the state also imposed resource tax on rare earth mining. In April 2011 the Ministry of Finance and State Administration of Taxation jointly issued a significant raise of the resource tax charged to rare earth mining,

[310] The mining license is for active mining projects; it is different from "exploration license" which is awarded to companies conducting exploration of mining resources.
[311] The mining quota data is calculated from the official quota release documents issued by MLR each year.

from 0.5-3 RMB/ton to 60 RMB/ton (for LREE) and 30 RMB/ton (for HREE). (PRC State Council, 2011) The real tax rate per extracted tonnage was in fact higher for the higher-valued HREEs: LREEs are usually five times more concentrated than HREEs in ores, thus producing the same volume of HREEs would incur higher resource tax compared to producing LREEs.

8.3.1.2 Regulatory and Policy Changes on Smelting Production

A new addition to state reregulation policies after 2008 is the control on rare earth smelting production. As the previous chapter shows, compared to the mining market with limited players due to restrictions in mining licenses and quota, the rare earth smelting market in China was much more competitive and showed chronic low-profit and over-production. NRDC, the supra-agency overseeing industry development prior to 2008, first issued a quota plan for rare earth smelting production in 2007. Then with the State Council Reform in 2008, MIIT took over the production planning and started issuing a formal "plan for rare earth production" (稀土生产计划) twice a year to each eligible central-government-controlled company and each provincial government. The local Economic and Information Technology Commission[312] within each provincial government would break down the planned volume and determine the quota for each eligible local producer. As shown in Figure 66, there was a 22% yearly decrease in smelting production plan in 2010, but gradual increase yearly afterwards. The smelting production quota for 2014 was 99300 metric tons in REO equivalents, a 16% decrease compared to 2008. Interestingly, MIIT, as the ministry overseeing industry-specific

[312] Economic and Information Technology Commission was created at each local provincial-level government following the 2008 State Council Reform to manage local economic affairs corresponding to the jurisdictions of the MIIT.

regulations and standards, has also devised and issued an annual “plan for rare earth mining” (稀土开采计划) along with the smelting production plan since 2008. This plan theoretically has the same function of setting a maximum amount of allowed volume for mining production as the MLR-issued mining production guidelines. Yet MIIT apparently did not consult or coordinate fully with MLR in the first two years of issuing the plan figures. As shown in Figure 67, MIIT’s mining plan was much higher than MLR’s in 2008 and 2009. The two plans did not equalize until 2010. This also explains the sudden drop of MLR’s smelting production plan in 2010 that is shown in Figure 66.

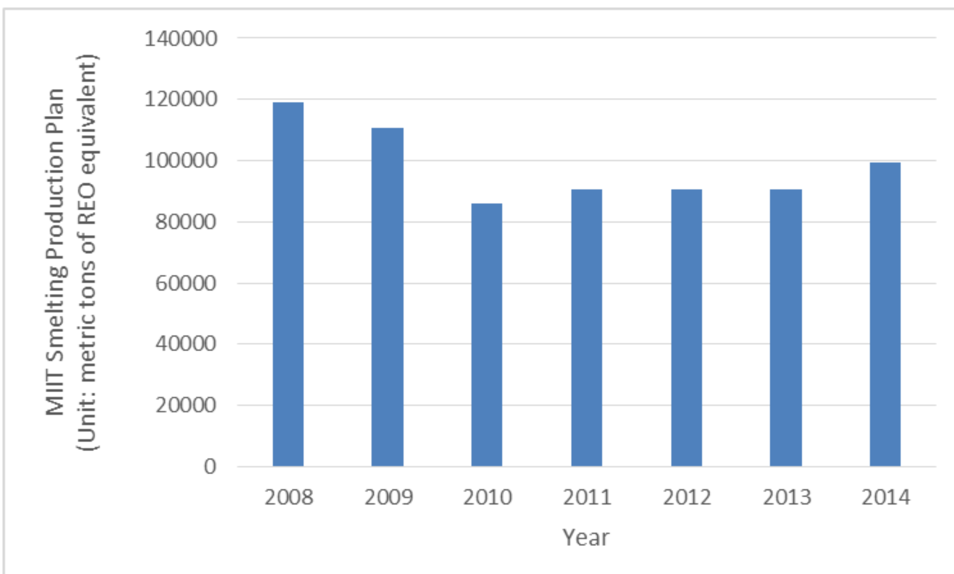

Figure 66 China’s Rare Earth Smelting Production Quota (2008-2014)[313]

[313] Data is extracted from the official plan release documents issued by MIIT each year.

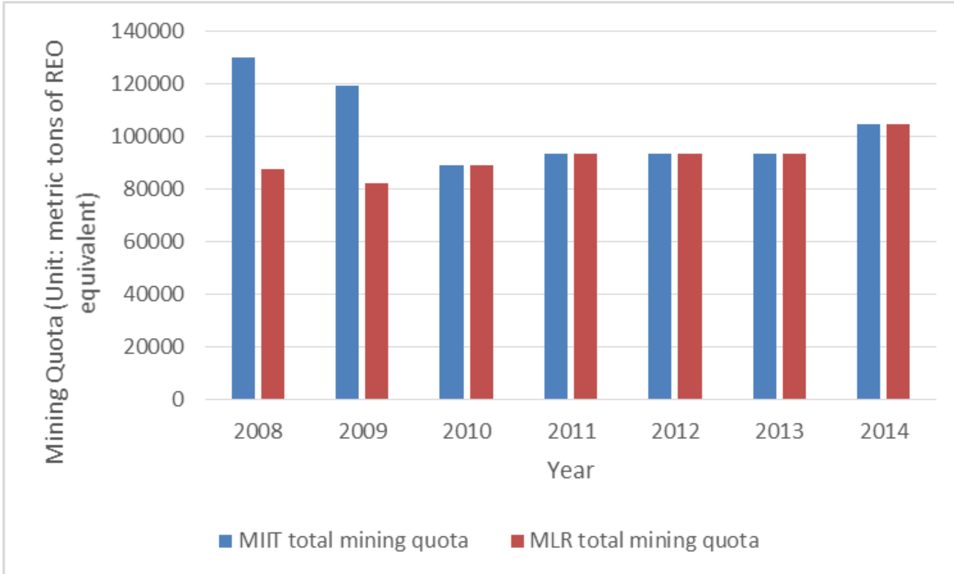

Figure 67 MLR-issued Rare Earth Mining Quota vs. MIIT-issued Rare Earth Mining Plan (2008-2014)[314]

Besides the smelting production planning, MIIT has imposed new standards for rare earth smelting market entry in order to push the small-scale local smelting producers out of the market. MIIT released a general *Guidelines for Industry Restructuring (2011)* in 2011 and an industry-specific *Entry Criterion for Rare Earth Industry* in 2012. According to the guidelines, rare earth separating projects with annual production capacity lower than 2000 tons (in REO unit), as well as LREE smelting projects with annual production capacity lower than 1500 tons (in REO unit) or Faraday efficiency lower than 85% or low-current electrolyzers (less than 5000 ampere) would not be eligible for market entry. (PRC MIIT, 2011; PRC MIIT, 2012c) Thus small-scale smelting producers not meeting the market entry standards, often local private small businesses, would be either closed or be merged into large-scale producers.

[314] Data is extracted from the official plan release documents issued by MIIT and MLR each year.

8.3.2 Regulatory and Policy Changes to Export

8.3.2.1 Export Quota

MOFCOM has made a series of changes, including some more restrictive measures, to the export of rare earth products. As shown in Figure 68, export quota issued by MOFCOM significantly declined in 2008 and again in 2010. More advanced products such as permanent magnets have still been excluded from quota, thus only the export of low-end smelting products were affected. A further calculation of quota allocation to domestic companies and foreign-domestic joint ventures shows that the quota allocation has decreased evenly for the two groups. As shown in Figure 69, despite of the quota decrease, export quota allocated to foreign-domestic joint ventures accounted consistently for about 24-30% of the total export quota.

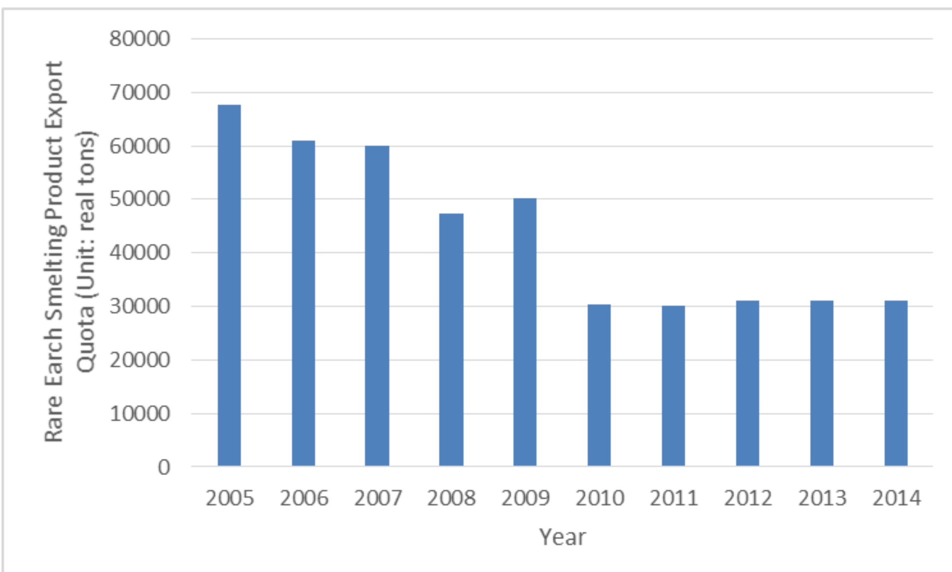

Figure 68 China's Rare Earth Smelting Product Export Quota (2005-2014)[315]

[315] Export quota data is extracted from the quota release documents by MOFCOM from 2005 to 2014. The author then calculates the sum of the export quota released during each year. China abolished its export quota and tariff on rare earth products in 2015 to comply with the WTO ruling on China's rare earth export restrictions. Thus this figure and all following figures of export quota show data until 2014.

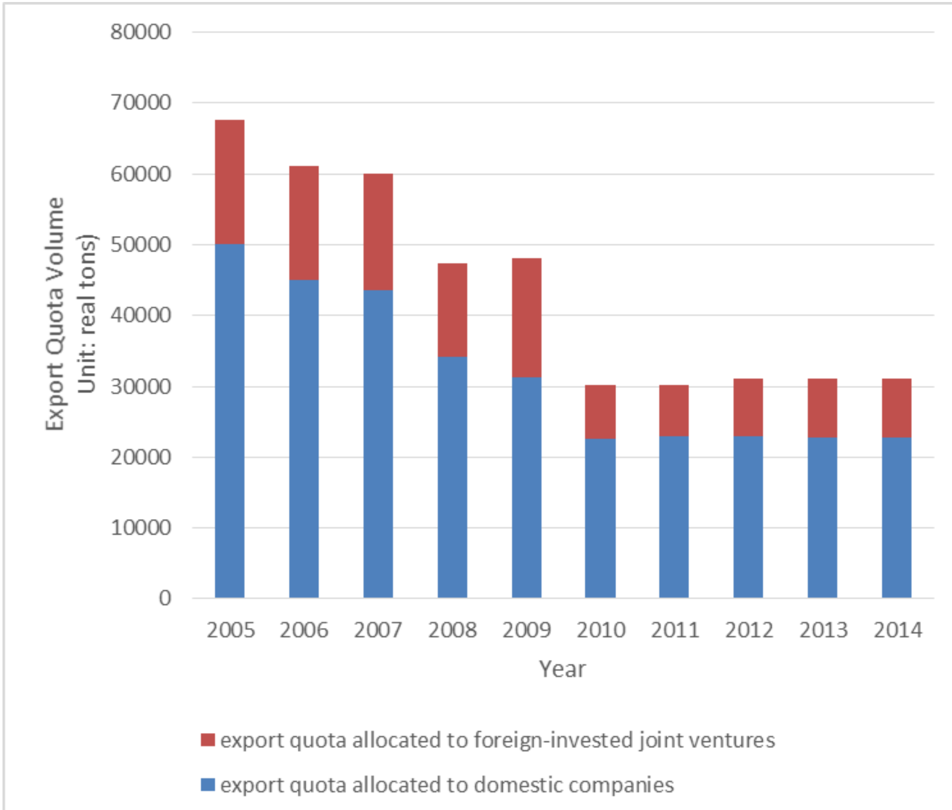

Figure 69 China's Rare Earth Smelting Product Export Quota Allocation to Domestic Companies and Foreign-Domestic Joint Ventures (2005-2014)[316]

Besides changes to the export quota volume, MOFCOM also changed the quota allocation mechanism and the eligibility criteria for exporting companies. Starting in 2012 MOFCOM made export quota allocation contingent upon the firm passing environmental inspections by the Ministry of Environmental Protection. (PRC Ministry of Commerce, 2011) Companies failing the MEP inspections, such as Baotou Steel,

[316] Export quota data is extracted from the quota release documents by MOFCOM from 2005 to 2014. MOFCOM stopped issuing separate quota release documents to domestic companies and foreign-domestic joint ventures in 2010, thus the author calculated the quota of the sum of each domestic company and each foreign-domestic joint venture extracted from the original export quota release documents.

received "provisional" export quota. The provisional export quota would become "confirmed" when the companies could pass the inspection within the year, or be allocated to other companies if they failed to pass the MEP inspection within that year. This was meant to incentivize companies to invest in environmental treatment facilities and comply with MEP's inspections.

Another major change in quota allocation was the separated export quota for HREE products and LREE products starting in 2012. Though MLR's mining quota clearly defined HREE and LREE mining, export quota released by MOFCOM prior to 2012 lumped HREE products and LREE products together. Since the quota only controlled the total volume instead of the value of export, exporting 1 ton of lanthanum oxide (LREE product historically priced around 40 RMB per kilogram) and exporting 1 ton of terbium oxide (HREE product historically priced around 2300 RMB per kilogram) would exhaust the same amount of quota. This drove export-eligible companies, particularly the trading companies, to export as much HREE products as possible. It further incentivized the production of specific higher-valued HREEs in South China, and it contributed to the prevalent illegal production (without mining license) and excessive production (production exceeding MLR mining quota) that the MLR had failed to eradicate. The cherry-picking of specific REEs for export by companies also resulted in persistent low recovery rates and huge waste (the technology of producing rare earth oxides used in southern China would ideally have a recovery rate of 50-70%, but the recovery rate in actual production was a low 20-50%). (Fang, 2010b) To curb this unsustainable production and export of the higher-valued HREEs, MOFCOM started in 2012 to allocate separated HREE and LREE product export quota to each export-eligible company. (PRC Ministry of Commerce, 2011) As shown in Figure 70, export quota allocation to HREE products in 2012-14 was consistently about 12% of the total export quota volume.

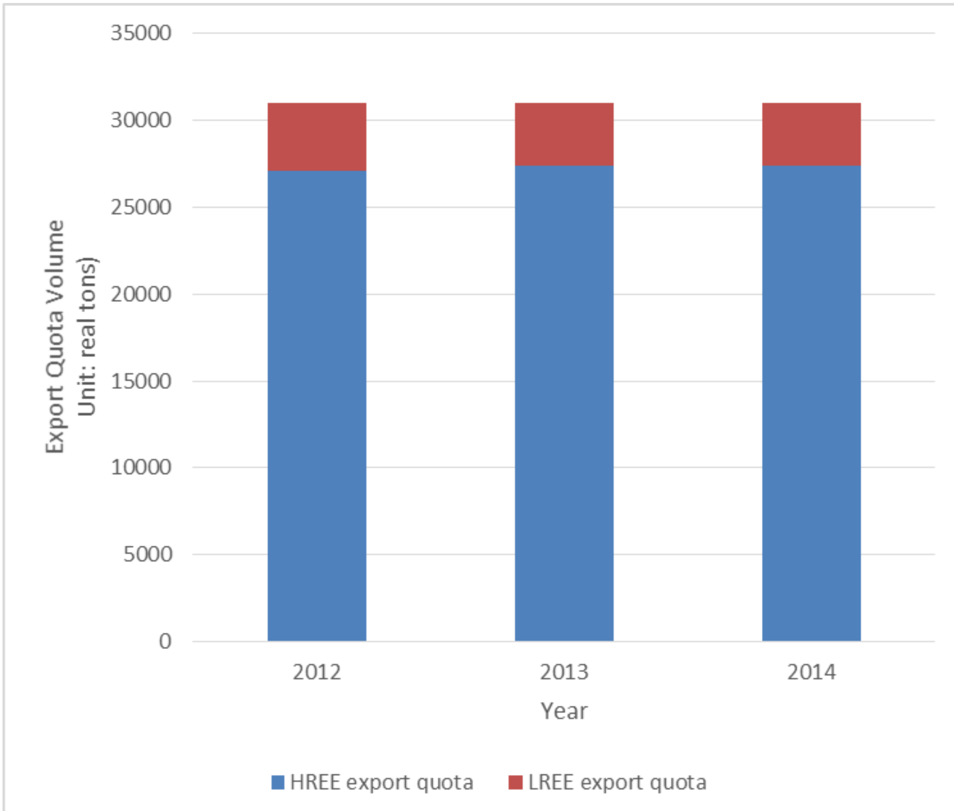

Figure 70 China's Rare Earth Smelting Product Export Quota Allocation to LREE and HREE products (2012-2014)[317]

8.3.2.2 Export Tariff

The PRC General Customs also significantly raised the export tariff on low-end rare earth products. In 2008 tariff on rare earth ferroalloys was raised from zero to 15%,

[317] Export quota data is extracted from the quota release documents by MOFCOM from 2005 to 2014. The author calculated the sum of the export quota for HREE and LREE products of each company.

on NdFeB alloys from zero to 20%, on rare earth products containing specific higher-value elements of Yttrium, Europium, Dysprosium and Terbium from 10-15% to 25%. (PRC Ministry of Finance, 2008) Table 7 shows General Customs' designated export tariff, rebate and licensing requirement for categories of products that rare earth products may fall in. Only the export of rare earth products that are directly used by downstream industries, including rare earth powder and compounds for lighting, pyrophoric alloys, NdFeB magnetic powder, rare earth alloyed steel powder, permanent magnets and NiMH batteries were not taxed. The "new materials products" under the campaign of "strategic emerging industries", such as permanent magnets, still received export tax rebate of 17% besides requiring no export licenses.

Table 7 China's Rare Earth Export Tariff and Licensing Regulation effective from 2009 to 2014[318]

Rare Earth Product Category	Product Category Number at Customs	Export Requirement	Export Tariff	Export Rebate
Rare Earth Metal Ore Concentrates	25309020	Export License	15%	N/A
Rare Earth Metals and Mixed Metals	280530	Export License	25%	N/A
Inorganic or Organic Compounds containing Rare Earth Metals or Rare Earth Mixed Metals	2846***	Export License	15% or 25%[319]	N/A
Inorganic Compounds for Lighting	32065000	N/A	N/A	N/A
Pyrophoric Alloys	36069011, 36069019	N/A	N/A	N/A
NdFeB Rapidly Solidified Permanent Magnetic Sheet	72029911	Export License	N/A	N/A
NdFeB Permanent Magnetic Powder	72029912	Export License	N/A	N/A
Other NdFeB Alloys	72029919	Export License	N/A	N/A
Other Rare Earth Ferroalloys	72029999	Export License	20%	N/A

[318] Data is extracted from General Customs' guidelines for export of each product category.
[319] Exception: zero tariff for No. 2846901991, phosphor compounds containing rare earth metals used for lighting.

Table 7 (Continued)

Rare Earth Alloyed Steel Powder	72052100	N/A	N/A	N/A
Rare Earth Permanent Magnets	85051110	N/A	N/A	17%
NiMH Batteries	85078010	N/A	N/A	15%

These changes in the export policies should not be viewed as the single moves of the Ministry of Commerce or the General Customs. Instead, the rare earth export policies were crafted to be synchronized with the other ongoing domestic policy campaigns (curbing environmental pollution, curbing the unsustainable rate of production, eradicating illegal mining, promoting industry upgrading, etc.) often primarily waged by the other ministries (MIIT, MLR, MEP, etc.). While other countries would naturally see China's export restrictions as primarily threats against the interests of their economies or national security , Beijing's view was in fact more inward-looking: "Export policies, such as quota, are the quickest and often the easiest government policies to implement in order to influence the behavior of enterprises"[320]. In other words, export policy was a tool and often the most convenient tool for Beijing's industrial governance, instead of an end of export restriction in itself.

8.3.3 Regulatory and Policy Changes on Industry Upgrading

Beijing has offered numerous funding schemes to rare earth companies for industry upgrading:

The first major form of support are large grants to research institutes, universities and companies for basic and applied research projects, allocated from the science and technology component of the Five-Year Plan. In the 12th Five-Year Plan (2011-2015), the science and technology component allocated funding totaling 350 million RMB for research projects related to the rare earth research and technologies. (Li, 2012)

The second major form of support is special fund for major players in the rare earth industry supply chain, including local governments, upstream mining and smelting

[320] Author interview with a senior researcher at MOFCOM in Beijing in January 2013.

companies (both state-owned and private) and midstream and downstream applications companies (mostly private). Following the 2011 release of *Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earth Industry*, MIIT and MOF jointly established a special fund for the rare earth industry in November 2012. The fund provided capital investment, cash bonus and grants to five categories of technology upgrading projects: 1. technology upgrading of mining and smelting companies for meeting environmental standards, with cash bonus of 500-1500 RMB per REO ton of production capacity for passing environmental inspection; 2. local governments' technological infrastructure development projects for regulating rare earth mining, with cash bonus of maximum 20% of project costs; 3. research and development of high-end REE applications and environmentally-friendly production technologies, with a maximum of 10 million RMB per project as state grants; 4. commercialization of high-end REE applications, with a maximum of 50 million RMB per project as state capital investment; 5. development of public technology service platforms, with a maximum of 50% of the previous year's total capital investment as state capital investment. (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2012) Following a fund extension in 2014, the MIIT-MOF special fund is still now active as "subsidy funding for rare earth industry". (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2014)

Thirdly, the state gives companies producing high-tech applications additional support through tax reduction. In 2008 MOST, MOF and State Administration of Taxation jointly released *Criteria for High-tech Company*. Based on a list of criteria including patents, product category (which has to fall within the categories listed in the

National High-tech Areas under State Priority Support Catalog), percentage of R&D spending by sales revenue, percentage of high-tech product revenue in total revenue (at least 60%), a company can apply to the local government's science and technology bureau to be recognized as a "high-tech company". (PRC MOST et al, 2008) Since rare earth materials falls into the category of new materials, a company producing high-tech applications, for instance high-end permanent magnets or rare earth lighting materials, can apply. If it receives the designation, the company would receive a corresponding lower tax rate and tax credits[321].

Finally, apart from all the funding support for research and development, the state also incentivizes, or in a more accurate word, "pressures" companies in a campaign style to invest in intellectual property. The State Intellectual Property Office (SIPO) maintains a trophy list of "National Intellectual Property Model Enterprise" (国家知识产权示范企业), in which companies have achieved a score higher than 90 in the SIPO scorecard on intellectual property. SIPO also maintains a similar trophy list of lower caliber called "National Intellectual Property Excellence Enterprise" (国家知识产权优势企业), in which companies have achieved a score higher than 80 in the SIPO scorecard. For local governments, having local companies selected into these two lists is an indicator of their excellence in governance in pushing forward indigenous innovation in their jurisdictions. Thus, the local governments would push local companies, including rare earth materials companies, to apply to be included in these two SIPO lists. Local bureau of science and technology and the local bureau of intellectual property would work with the targeted companies in filing patent applications. If a company is selected as a model/excellent

[321] Author interview with a senior manager at a major private rare earth permanent magnet company in Anhui Province in March 2013.

enterprise in intellectual property, it would receive additional government funding as reward; yet in return the company has to satisfy the requirement of submitting a certain "quota" number of patents every year[322]. As a manager of a rare earth materials company that the author interviewed put it, "we get money from the government as long as we keep applying for patents".

Besides providing support for technology upgrading, MIIT has also recently started tackling the overcapacity of the industry through closing down low-tech production lines. The rare earth industry was listed in MIIT's designated list of industries where companies may be required to abandon or replace production lines using "backward technologies". In August 2014, for the first time MIIT included 28 rare earth companies producing rare earth oxides in the list requiring the replacement/abolishment of outdated production lines. (PRC Ministry of Industry and Information Technology, 2014a)

8.3.4 Industry Restructuring and M&A focusing on Vertical Integration

Despite of the failure to consolidate the rare earth industry into two state-owned corporations in 2002-2005, the State Council again made the industry restructuring a major task of the current reregulation. In the 2011 *Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earth Industry*, the State Council vowed to "in one or two years have the rare earth industry led by large enterprises, and the industrial concentration of the top three enterprise groups in the ionic-type rare earth industry in south China will reach 80% or higher". (PRC State Council, 2011b) Such restructuring, if successful, would achieve several results in the

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[322] Author interview with a rare earth magnet firm manager in Anhui Province in March 2013.

rare earth industry that Beijing deemed important. Restructuring would raise the barrier to market entry high enough so that small-scale producers would be closed or merged, leading to an economy of scale on resource utilization, less production capacity and less resource waste. Restructuring would consolidate the industry into only several SOEs as major market players. This would make it easier for Beijing to implement and enforce its industrial policies through supervising the few SOEs instead of regulating the existing few hundreds of companies in the market.[323] Thirdly, compared to the current buyer's market with persistent low pricing, an oligopolistic market would be more likely to maintain higher prices through price alliances or coordinated supply cut[324]. Finally, restructuring would allow central SOEs a larger share of the pie in the industry and the access to the entire supply chain. As the previous chapter explains, the central SOEs had woefully poor control of the upstream mining resources, particularly in South China where the mining rights and licenses of higher-valued HREEs were almost entirely controlled by the local provincial/prefectural governments. A restructuring of the industry favoring the vertical integration of companies in the different stages in the production chain would give the central SOEs an upper hand in the upstream.

Yet the industry restructuring process had significant pushback from the local governments and local companies, and the negotiation among companies for mergers and acquisitions took place much more slowly than the State Council planned. As one local

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[323] Author interview with a professor and long-term researcher of rare earth industry in Jiangxi University of Science and Technology in Ganzhou, Jiangxi Province in July 2013.
[324] It should be noted that an oligopolistic market does not automatically lead to price increase. Oligarchies may choose to maintain low pricing or increase supply in times of low market demand to further stimulate the market demand or to slow the adoption of substitute products. However, compared to a perfectly competitive market of hundreds of players, an oligopolistic market consisting of a few firms would be more likely to coordinate a higher price due to less supplier competition.

rare earth company manager in Baotou that the author interviewed put it, "a quick restructuring pushed forward primarily by the government would only be possible under a planned economy"[325]. The original restructuring plan of the State Council was a vertical integration of merging the entire industry upstream, including companies at different stages (mining, sorting, smelting and low-end production) into just two or three state-owned conglomerates by 2012. In reality, chaos ensued, with much fighting amongst companies of different ownership structures, between local governments and their local SOEs, as well as between the localities and the central government. For the more than two hundred small-scale and median-scale local smelting companies, many of which are private, industry restructuring means they would very likely be merged into a larger state-owned company, or be closed down. Thus they have resisted the restructuring mandate, bargaining with the local government and local SOEs for survival, fair compensation and fair terms of mergers. For the SOEs owned by provincial/prefectural governments, industry restructuring has been both a battle for the support of the local government and a battle against local SOEs of other provinces/prefectures. Since there would be eventually very few local SOEs from one region allowed to be on the State Council's list of conglomerates, support from their own provincial/prefectural government would be critical. The central SOEs, with little mining rights of their own, have also waged into the fight to get on the coveted list of conglomerates. The central SOEs battled amongst themselves and against local SOEs to access the mining licenses and mining rights.

Thus the restructuring process has been nothing but chaotic and dragged far behind the State Council's original deadline. In 2014 MIIT finally selected 6 companies

[325] Author interview with a senior manager of a major private rare earth magnet company in Baotou, Inner Mongolia in August 2013.

as major rare earth conglomerates to remain in the industry upstream, including 2 central SOEs (China Minmetals, CHALCO) and 4 local SOEs (Baotou Steel, Ganzhou Rare Earths, Guangdong Rising, Xiamen Tungsten). In 2015 MIIT began to directly issue the smelting production plan to the six chosen companies. (PRC MIIT, 2015)

8.3.5 Campaign against Illegal Mining and Smuggling

Beijing has declared a war against illegal mining and smuggling, with an inter-agency special campaign involving inspectors dispatched to the local regions almost every year. The Ministry of Industry and Information Technology (MIIT), Ministry of Public Security (MOPS), Ministry of Land and Resources (MLR), Ministry of Environmental Protection (MEP), General Administration of Customs, State Administration of Taxation, State Administration for Industry and Commerce and State Administration of Work Safety jointly conducted a "Special Campaign to Crack Down on Violations of Law or Regulation Regarding Rare Earths" lasting half a year in local production regions in 2011, 2012, 2013 and 2014. (PRC Ministry of Industry and Information Technology et al, 2011; PRC Ministry of Industry and Information Technology et al, 2013; PRC Ministry of Industry and Information Technology et al, 2014) These special campaigns from Beijing were commonly referred to in the media and among industry professionals as "crackdowns" (打黑). During a crackdown, the State Council ministries sent two inter-ministry inspector groups ("查处稀土违法违规行为督查组") to North China and South China; each group would visit the major producing provinces to monitor the local government campaign against illegal operations, and it would conduct spot checks on select rare earth mining, smelting and trading companies. To incentivize the public to report illegal activities, starting in 2012 the Association of

China Rare Earth Industry sought tips about illegal operations from the public and provided cash rewards of 50000 RMB for each correct tip[326]. At the local level, the provincial governments and prefectural governments implemented crackdown campaigns corresponding to the state crackdown campaign in local counties. Local county officials were required to sign "responsibility letters" in which they pledged "no illegal activities within their jurisdictions", thus if illegal activities were found and reported, local officials would be terminated[327].

Modern digital technologies, such as digital surveillance, satellite imaging and digital invoice tracking have been employed to aid the campaign against illegal mining and smuggling. Because rare earth mining regions in South China are mostly in mountainous areas not easily accessible by modern transportation, the Ministry of Land and Resources expanded the use of its remote sensing satellite system to detect illegal rare earth mining activities with precision to the county level[328]. To reduce the circulation of illegal products, the State Administration of Taxation introduced a special invoice system in the rare earth industry that provides tracking of rare earth products through invoices. (PRC State Administration of Taxation, 2012) The MIIT-MOF joint special fund for the rare earth industry since 2012 has provided funding for local governments to install infrastructure necessary for on-the-ground inspections and digital surveillance systems. (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2012) For instance, in campaign against illegal mining in Baiyun-ebo region, the Baotou

[326] Author interview with an officer at the Association of China Rare Earth Industry in Beijing in July 2013.
[327] Author interviews with a local county government official in Ganzhou, Guangdong Province during the crackdown campaign in July 2013.
[328] Author interview with a local county land and resources bureau official in Guangdong Province in June 2013.

Prefecture Government installed a digital surveillance platform to complement on-the-ground law enforcement efforts by the local Baiyun District police. Baotou Steel also installed a surveillance system in the mining region, consisting of 2 central stations and 627 cameras to complement 24-hour inspections by a 190-person patrol team. (PRC MIIT, 2013)

8.3.6 Campaign for Clean Production and Pollution Treatment

Beijing has waged a much stronger campaign to institutionalize clean production and pollution control in the rare earth industry compared to the previous period. After much delay, in 2009 the Ministry of Environmental Protection (MEP) finally publicly released the draft of *Emission Standards of Pollutants from Rare Earth Industry*, an industry-specific pollutant emission guideline which came into force in 2011. (PRC MEP, 2009; PRC MEP, 2011a) In 2011 MEP also released *Opinions on Strengthening the Protection, Treatment and Restoration of the Ecological Environment of Rare Earth Mines.* This law requires all rare earth mining companies to pay Deposit of Mining Environmental Restoration (矿山环境治理恢复保证金), a security deposit managed by the local environmental protection bureau. The deposit would be returned to the mining companies if they are able to restore the ecological environment of a mining site to comply with state environmental standards after finishing the mining operation there. (PRC MEP, 2001b) This allows the external cost of environmental restoration to be internalized in the cost of production, and it also helps relieve the burden of the local government in cleaning up the pollution by shifting the financial responsibility to the companies. MEP has also participated in the yearly state crackdown campaigns since 2011. MEP first required local provincial-level environmental protection bureaus to conduct environmental inspections of rare earth companies in their own jurisdictions. Companies failing the inspections would need to pay fines for violation and install environmental treatment facilities to reduce their pollution, or get rid of high-polluting production lines and replace them with more efficient and environmentally friendly lines. For companies that passed local inspections, MEP then dispatched expert inspector teams to conduct a second inspection. (PRC MEP, 2011c) The list of companies which complied with both inspections was then disclosed on the MEP website and shared with other State Council ministries. From 2011 to 2014, MEP has conducted four batches of inspections and publicized on its website the names of rare earth mining, smelting, alloy making and applications companies (totaling 87 in number) that passed MEP inspections. (PRC MEP, 2011d; PRC MEP, 2012a; PRC MEP, 2012b; PRC MEP, 2013) In 2015 NDRC, MEP and MIIT jointly released *Evaluation Indicators System for Clean Production for Rare Earth Smelting Industry*, providing specific standards for clean production in the inspection of rare earth smelting companies (PRC National Development and Reform Commission et al, 2015)

Other State Council ministries have also pitched in to make environmental compliance part of their policy measures. Starting in 2012, the MIIT-MOF joint special fund for the rare earth industry specifically allocated cash bonus (500-1500 RMB per metric ton of REO equivalent of production capacity) to rare earth mining and smelting companies for passing the MEP environmental inspection. (PRC Ministry of Finance & Ministry of Industry and Information Technology, 2012) Also starting in 2012, both MOFCOM's export quota and MIIT's smelting production quota required companies to pass the MEP environmental inspections to qualify for application for quota. MIIT's market entry criteria which came into force in 2012 also included compliance with MEP environmental inspection as criteria for market entry. (PRC Ministry of Commerce, 2011; PRC Ministry of Industry and Information Technology, 2012)

8.4 Examination of Beijing's Alleged Rare Earth Export Halt to Japan

This section specifically addresses Beijing's alleged rare earth export halt to Japan in 2010. Although Beijing's intensified reregulation started in 2008-09, it was not until the second half of 2010 that China's rare earth policies gained worldwide attention. The trigger was Beijing's alleged halt of rare earth export to Japan after the Senkaku/Diaoyu Island incident. This section is specifically devoted to analyzing this incident through an analysis of key events and evidence along the timeline surrounding the incident in the second half of 2010, as many believed it to be the evidence that China was using its rare earth resource as a leverage in international security standoffs against its neighbor.

Beijing's official stance is that there was no such thing as intended halt of export. In the authors' interviews with industry stakeholders in Beijing, all interviewees also refused such a notion of Beijing halting rare earth export. A senior researcher at MOFCOM remarked that "there is no way and no sense for China to ban the export of rare earths to a major advanced economy"[329].

The issue of China's rare earth export quota restrictions, notably the significant quota decrease, was already a high-level concern among government officials from Beijing and Tokyo before the Senkaku/Diaoyu Island incident. As China started tightening its REE export quota and increased export tariff in 2008, the issue of rare earth

[329] Author interview with a senior researcher at MOFCOM in Beijing in January 2013.

export restrictions was put on the agenda of economic issues at the Third Sino-Japan High-Level Economic Dialogue set to begin in late August 2010. Just in July 2010, China also announced that it would reduce its second-half-year quota (taking effect in August) for 2010 to 7976 tons, about 60% reduction compared to the first-half-year quota of 2010. Japanese officials at METI expressed serious grievances immediately after the announcement, and the parliamentary secretary of METI travelled to Beijing but did not succeed in persuading Chinese to keep the export quota at 2009 level. (Hagstrom, 2012) During the Sino-Japan High-Level Economic Dialogue meeting, the Minister of METI Naoshima Masayuki raised concerns about the rare earth export restrictions. Minister Naoshima argued that the export quota decrease would lead to decreased supply and significant price increase, which would hurt Japanese manufacturers such as producers of computer hard drives, automobiles and clean energy products; Japanese manufactures in turn would raise the price of their downstream products, which would indirectly hurt both the Chinese consumers and the development of Chinese high-tech industries. (Teng, 2010; Ito, 2010) The Chinese Minister of Commerce Chen Deming responded that the export quota decrease was part of the larger campaign by Beijing to regulate the industry, driven by three major concerns, namely restructuring the industry by weeding out small-scale and polluting companies, reducing the environmental damage from mining production, as well as ensuring the long-term availability of domestic resources to avoid depletion. (Teng, 2010) The Japanese Ministry of Foreign Affairs speaker Satou Satoru remarked in a press conference on August 29 that China regarded its rare earth export restrictions as "a policy measure that cannot be helped." (Ito, 2010) The Japan-China Economic Association sent a large delegation of more than 160 Japanese business representatives, headed by the Chairman of Toyota, to Beijing on September 5th to discuss the impact of China's rare earth export with the Chinese government officials. At the meeting on September 7th, Luo Tiejun, the Vice Chief of the Bureau of Raw Materials Industries at MIIT, reiterated that China would not raise the export quota for the second half of 2010. Responding to the concern of Japan's lack of supply, Luo reportedly said that "Canada, Australia and the United States all have developed rare earth mines, it is our hope that Japan would diversify its supply sources." Luo also said that "because there are also inquiries from other importing countries besides Japan, we would take some consideration." (J-CAST News, 2010)

On September 7th 2010, a Chinese trawler collided with two Japanese coast guard vessels in the disputed waters near the Diaoyu/Senkaku Island, and the trawler's captain was brought to a local court in the Ishigaki Summary Court in Okinawa Prefecture and was detained on "suspicion of deliberately ramming the vessels." (Nakano, 2011) On September 22, the New York Times reported from Hong Kong and Tokyo that China had halted its rare earth export to Japan citing industry sources, and the news report linked the halt with the ongoing Diaoyu/Senkaku Island incident and Japan's arrest of the Chinese captain. (Bradsher, 2010a) Subsequently major Japanese media reported about the alleged export ban and the linkage with the arrest, based on the New York Times report. (see for instance Matsuo, 2010; Jiji Press[330], 2010) The P.R.C. Foreign Ministry denied allegations of rare earth embargo and also swiftly denied news that China would further

[330] Jiji Press［時事通信社］is the second largest press in Japan, specializing in news on economy.

reduce the rare earth export quota in the coming year[331]. In early October, METI released a poll result from 31 Japanese trading companies with rare earth import businesses and reported that there were 13 instances of delay in rare earth export. (METI, 2010) The reported reasons for delay were various: 1. time delays in the approval of export license for shipments; 2. export price deemed too cheap by the customs inspectors to grant approval; 3. besides the usual English-language documents, additional Chinese-language documents were required for application for export license and customs clearance; 4. time delays in shipment after customs approval; 5. increased customs inspections of the products waiting to be shipped after customs approval. (METI, 2010) Though the Chinese captain was freed on September 25 as a peaceful end to the Senkaku/Diaoyu Island incident, Sino-Japan high-level government bilateral exchanges did not resume until late October of 2010. Meanwhile, the New York Times reported on November 10 that China blocked shipments of rare earth minerals to Japan since Sept. 21 and some shipments to the United States and Europe since mid-October. (Bradsher, 2010b) The alleged embargo of China's rare earth exports lasting two months led to wide speculation that China was using rare earths as a geopolitical weapon in its territorial disputes with Japan.

If there was indeed an embargo, then the Japanese import data would show import of rare earths from China decreased to nearly zero. The alleged rare earth export embargo was started before September 21 (Bradsher, 2010a) and lasted until at least early November. (Bradsher, 2010b) Using official Japanese rare earth import data reported by the Japanese Ministry of Finance, the author charted Japan's import of several rare earth

[331] In fact annual export quota since 2010 until 2014 has been almost constant with slight increase (see Figure 68).

oxide products from China. Figure 71 shows that the import of cerium oxide, yttrium oxide, lanthanum oxide and rare earth metals were all reported consistently from September 2010 to November 2010. Compared to the second half of the year 2010, the import volume changes were fairly volatile in the first half of the year 2010. Figure 72 shows the import of cerium oxide, yttrium oxide, lanthanum oxide and rare earth metals from China in 2009. The import volume changes in the previous year were even more volatile, while there was no claim of an embargo then. Thus the alleged embargo could not be substantiated based on the official import data available.

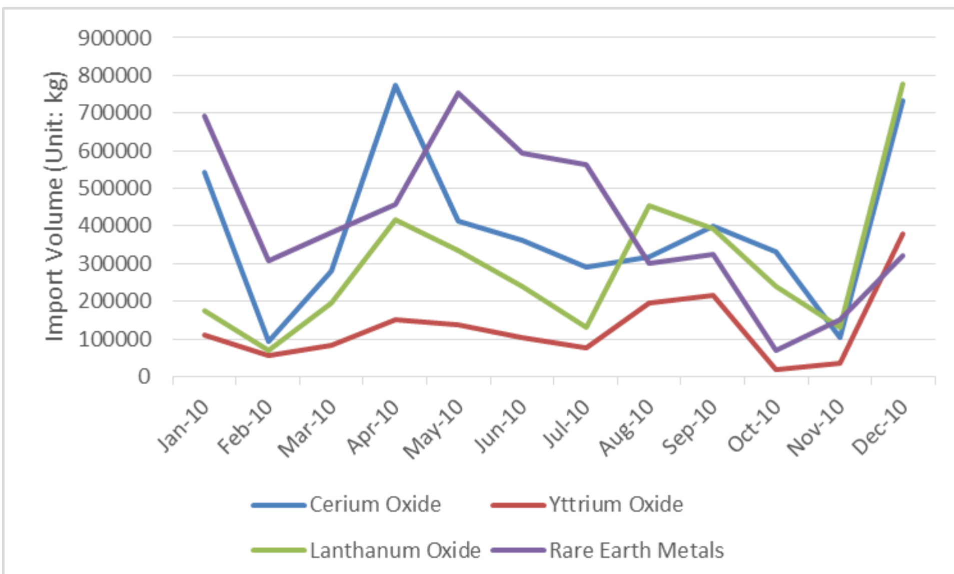

Figure 71 Japan's Imports of Cerium Oxide, Yttrium Oxide, Lanthanum Oxide and Rare Earth Metals from China by Month in 2010[332]

[332] Data is extracted from the Ministry of Finance Trade Statistics of Japan database at http://www.customs.go.jp/toukei/srch/indexe.htm. Country code for China is 105. Commodity codes for cerium oxide, yttrium oxide, lanthanum oxide and rare earth metals (including scandium and yttrium) are 284610010, 284690210, 284690220, 280530000.

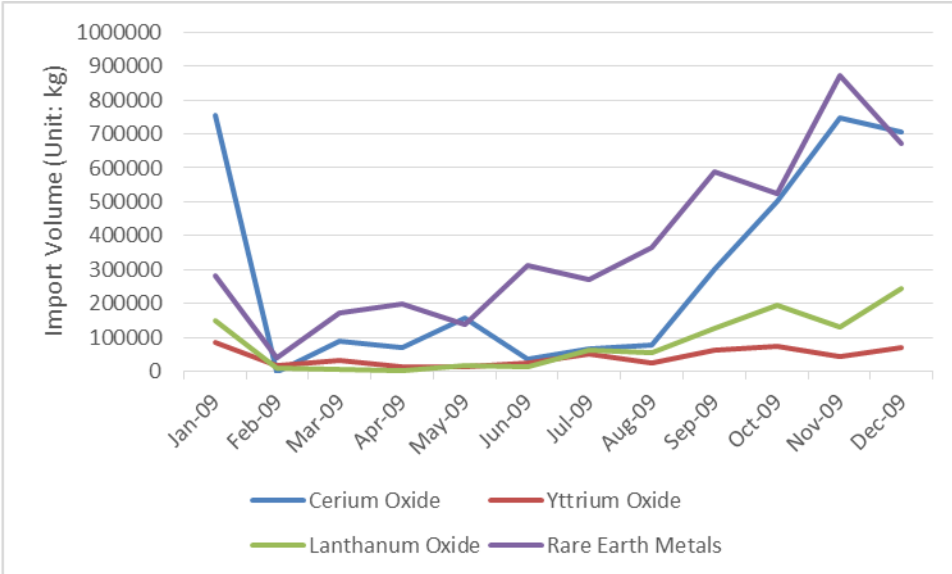

Figure 72 Japan's Imports of Cerium Oxide, Yttrium Oxide, Lanthanum Oxide and Rare Earth Metals from China by Month in 2009[333]

The reported "delay" of rare earth exports to Japan reported by the Japanese trading sources was likely the result of Beijing's ongoing domestic policy campaigns over rare earth mining which met up against a drastically cut half-year export quota. The rare earth export quota was allocated by MOFCOM to individual companies (both domestic companies and foreign-domestic joint venture companies) on a half-year basis. For Japanese consumer companies, because there was never an international "rare earth metal exchange", buying rare earth products was through company-to-company contracts with Chinese export-eligible smelting companies or intermediary traders. When MOFCOM announced the export quota decrease in July, other State Council ministries were also increasing their inspections over companies in the rare earth business. From June 2010 to November 2010, the Ministry of Land and Resources conducted a nationwide crackdown

[333] Data is extracted from the Ministry of Finance Trade Statistics of Japan database at http://www.customs.go.jp/toukei/srch/indexe.htm.

on illegal operations in rare earth mining, including both mining production without licenses and mining production beyond the MLR-allocated quota. Inspector teams were sent to each major producing province to conduct spot checks on mining operations. (PRC MLR, 2010a) Also in October 2010, it was reported that facing a dismal record of catching smugglers in the previous three years, several ports of the Chinese Customs had been conducting special anti-smuggling campaigns focusing on the rare earth export, increasing the percentage of shipments subject to customs checks and increasing the auditing of trading companies. (Zhang, 2010) These inspections, audits and spot checks could very likely result in delays in the approval of export licenses or shipments of rare earth products from the Chinese ports. It is also possible that the export companies or intermediary traders could not complete the shipments with overseas customers in time, because their sources of supply involved illegal mines or extra-quota production that were cracked down by the MLR inspection. Furthermore, because the MOFCOM export quota still did not differentiate between higher-value HREEs and lower-value LREEs in 2010, it was also very likely that exporting companies or traders would temporarily withhold the export of cheaper rare earth products in order to bid up the price, or to make room for the export of more expensive rare earth products first.

After the 2010 Diaoyu/Senkaku Island incident, both Beijing and Tokyo governments hoped to resume bilateral dialogue over the rare earth trade issue. At the Sino-Japan Economic Forum in September 2011, a meeting involving both Japanese and Chinese government officials and business representatives, a close resemblance to the early Sino-Japan Rare Earth Communication Conference, was proposed to be held in Beijing in April 2012 (2012 marked the 40^{th} anniversary of the normalization of relationships between China and Japan). (Nikkei, 2012) However in April 2012 the proposed conference was cancelled. Although no official reason was given, it is possible that the cancellation was influenced by the rising tension between Japan and China in April 2012, when controversial Tokyo Governor Ishihara Shintaro announced plans to purchase three islands at Diaoyu/Senkaku disputed water area in order to claim ownership over the territory. (Fang, 2010) Another possibility is that Japan had already announced in March 2012 the filing of a joint WTO complaint (DS431) with the U.S. and the E.U. against China's rare earth export restrictions, which might have increased tensions between China and Japan over the rare earth trade issue.

8.5 National-level Institutional Changes

This section analyzes the key national-level institutional changes in this period that influenced the capacity of the state to steer China's rare earth industry development. The increased inter-ministry policy coordination within the State Council, a local cadre evaluation system with more balanced incentives and less dual administrative control, and cross-regional cooperation in law enforcement have contributed to better enforcement of Beijing's reregulation policies. However, the continued lack of independence in local cadre inspection and the lackluster criminal punishment still created incentives and rooms for market actors to evade Beijing's mandates.

8.5.1 Increased Inter-ministry Policy Coordination within the State Council

In an attempt to recentralize its bureaucratic control over the industry, the State Council has created new institutions for central inter-agency cooperation in devising, implementing and enforcing its policy campaigns. The 2008 State Council Reform resulted in the partial transfer of responsibility over industrial governance from NDRC to a new ministry, the Ministry of Industry and Information Technology (MIIT)[334]. NDRC still remains perhaps the most powerful agency in the current State Council, making macro-level economic development and reform policies, approving/vetoing large-scale industrial projects and setting price controls affecting all industries[335]. NDRC also retains its Department of High-Tech Sectors (高科技产业司) which devises national-level development policies focusing on strategic emerging industries and has the authority to approve and review large-scale high-tech sector projects. MIIT on the other hand primarily manages the details of industrial development, such as devising and implementing industry-specific policies, standards and regulations. MIIT's Bureau of Raw Materials industries, which retained staff members from NDRC, oversee the details of industrial development in raw materials industries including the rare earth industry. The Rare Earth Office, whose bureaucratic authority was reduced to be a lower-level unit within NDRC in the 2003 State Council Reform, remained a lower-level unit under the Bureau of Raw Materials industries of MIIT.

In 2009 the State Council approved a new "Rare Metal Management Inter-Ministry Coordination Regime" (**稀有金属管理部际协调机制).** This interagency effort has been primarily led by MIIT and attended by 12 State Council ministries and commissions, including NDRC, MOF, MLR, MEP, MOFCOM, MPS, General Customs and State Administration of Taxation. (PRC MIIT, 2009) Since 2009, MIIT has chaired

[334] MIIT took over the responsibility of central government oversight over the civilian industries from NDRC, as well as the responsibility of oversight over defense industries and technologies from COSTIND (abolished in the 2008 State Council Reform).
[335] The Pricing Department at NDRC is nicknamed "Most Powerful Department under the Sun" (天下第一司) in China, as it currently controls the pricing of most basic industrial and service products including agricultural products, energy and natural resources (water, natural gas, electricity, coal, etc.), transportation, information and communication, real estate, healthcare services and drugs, and social service.

annual meetings of this inter-agency regime convening staff from the relevant offices in the 13 ministries and commissions, representatives of major central SOEs, representatives of major industry associations and rare earth industry experts. The annual meeting works to ensure the coordination in policy formulation and implementation regarding the rare metals, including the REEs. In terms of monitoring and evaluation, as the previous section explains, several major State Council ministries, including MIIT, MLR, MEP and General Customs have jointly conducted annual special operations cracking down illegal operations, conducting spot checks on rare earth companies in ten major production regions. (PRC MIIT, 2011)

The State Council still had some incoherence in policies where one ministry's policy trumped another. For instance, as the previous section explains, the mining production plan quota between MIIT and MLR was not equal until 2010, and the smelting quota released by MIIT was based on the higher MIIT mining plan quota. This created confusion and loophole in the quota implementation in local production regions. Some local smelting companies which were allocated production quota from MIIT could not buy enough rare earth concentrates as raw materials to fulfill their production quota[336].

8.5.2 Changes to Local Cadre Management System

A few new changes to the monitoring and evaluation of local party cadres after 2008 have influenced the local enforcement of central policies. Firstly, as the previous chapter analyzes, the evaluation of local cadre performance was historically focused on economic growth indicators such as GDP. This primary focus on economic growth has not seen much change. Until most recently in 2015, a measure of "Green GDP" was out

[336] Author interview with a senior officer at Association of China Rare Earth Industry in Beijing.

of the consideration. (Ye, 2015) However, because Beijing and local provincial governments have conducted several rounds of crackdowns and inspections in the rare earth industry, compliance with central policies in the inspections of local production regions has become a key factor in local cadre tenure. For instance, during the author's fieldwork in Ganzhou Prefecture in Jiangxi Province in the summer of 2013, the county party secretary and several county party officials of Anyuan County were terminated and persecuted following an inspection which uncovered their involvement in illegal mining activities in the county. This creates disincentive for the local cadres to evade Beijing's policies, at least during the inspection and crackdown seasons.

Secondly, the central party authority has implemented new measures strengthening higher-level control over cadre monitoring and evaluation institutions. The Amendment to the PRC Administration Inspection Law in June 2010 stipulates that dispatched inspectors to government agencies and SOEs would no longer be subject to "dual management", and they would only report to the discipline inspection agency[337]. Thus at least the dispatched inspectors have gained a higher degree of independence in their work.

However, greater institutional changes in cadre management system are necessary to ensure enforcement of central policies by local cadres. Local discipline inspection and supervision officers in local governments have still been under "dual management", and thus they still suffer from a lack of independence from the rest of the local bureaucracy. ((Liu & Li, 2014) Similarly, local environmental protection bureau officers, as part of the

[337] See the full text of the amendment at
http://politics.people.com.cn/GB/1026/11978021.html

local bureaucracy, also suffer from a lack of independence. This has led to the relatively lax enforcement of Beijing's pollution discharge regulations in some counties[338].

8.5.3 Changes to Law Enforcement Mechanisms

8.5.3.1 Increased Collaboration in Law Enforcement across Regions

As the previous chapter analyzes, the mining rights and licenses have been under the control of local provincial/prefecture governments through their local SOEs. For Beijing to enforce its reregulation campaign, cross-regional collaboration between local authorities would be necessary. Thus the post-2008 State Council has pushed for more cross-province collaboration in regulating the local businesses in the rare earth industry.

So far two regional regulatory regimes have been established covering HREEs and LREEs. In 2010, under the coordination of MLR, 15 prefecture governments in five provinces (Fujian, Jiangxi, Guangdong, Guangxi, Hunan) in South China signed an agreement to form a joint regulatory regime to coordinate regulation over heavy rare earth production. (PRC MLR, 2010) This 15 Prefecture Rare Earth Development Regulation Regional Joint Operation (15 市稀土矿产开发监管区域联合行动) agreed on cross-regional regulations on issues including the coordination of mining quota, the crackdown of illegal production and smuggling, the management of law enforcement personnel in mining operations. In 2011, MLR also coordinated a similar cross-regional agreement between 3 prefectures producing light rare earth products, including Baotou in Inner Mongolia, Jining in Shandong Province and Liangshan in Sichuan Province. (PRC MLR, 2011) This Light Rare Earth Development Regulation Regional Joint Operation (轻稀土矿产开发监管区域联合行动）between the three local governments agreed on

[338] Author interview with a university researcher in Jiangxi Province in July 2015.

cross-regional policy campaigns over a number of issues, including crackdowns on illegal mining and smuggling, coordination of production planning, coordination of smelting production and sales, law enforcement and coordination of metals stockpiles.

8.5.3.2 Lack of Strong Legal Rules to Prosecute Illegal Activities

While Beijing has implemented a series of crackdowns (打黑) and special operations (专项行动) in enforcing regulations and restrictions over the rare earth industry, its legal institutions (法规) have not caught up with its whirlwind campaign-style policies with changes to turn around the lax prosecution. As the previous chapter analyzes, prior to 2008 the local prosecution of illegal mining was difficult, and the penalty of less than 3 years of jail time was too miniscule to deter businesses from the profits they would pocket from illegal operations. While Beijing's crackdowns and special operations since 2008 have made spot checks and thus prosecution easier, the lax penalty for illegal operations (illegal as defined by Beijing's policies) still persists.

The PRC Mineral Resources Law, last amended in 1997, only contains prohibitions against mining without legal licenses. The prosecution of illegal mining, under the Mineral Resources Law, would only result in confiscation of revenues and administrative fines unless there is persistent illegal activity and significant damage which warrants criminal prosecution (刑事犯罪)[339]. In Guangdong Province for instance, the illegal mine operators would only be persecuted in the criminal court if the illegal operation results in compromised mineral resources assessed above 50000 RMB. Even when an illegal mine operator ends up in the criminal court, according to the PRC Criminal Law, illegal mining crime would result in a sentence of just under 3 years, and

[339] Article 39 of the PRC Mineral Resources Law.

under the circumstance of extremely significant damage, a sentence of under 7 years. Thus in reality, the prospect of illegal miners going to jail for more than a few years is highly unlikely.

Furthermore, the current court system has very little to offer to satisfy Beijing's strong campaigns in regulating the rare earth market actors besides upstream mining. Beijing's restrictions over rare earth mining and smelting, as well as its addition of resource taxes, have resulted in a higher pricing of rare earth products legally sourced in the market, compared to the illegal rare earth products circulated in local black markets. This creates incentive for companies to use illegal products as long as they can avoid being caught and prosecuted. Because the Mineral Resources Law only applies to the mining of mineral resources, companies involved in the selling and buying of illegal rare earth products within China cannot be prosecuted under the Mineral Resources Law[340]. The PRC Criminal Law allows prosecution against "illegal operation crime" (非法经营罪), which is defined as business activities violating "laws and decisions made by the National People's Congress and administrative laws and regulations released by the State Council"[341]. However, the restrictions over the rare earth market released by the State Council have been primarily in the form of "announcements", "suggestions" or "plans", which opens the legal debate of whether these regulations can be elevated to the status of national laws. In practice it is very much up to the local prosecutors and the local court to determine the extent of criminal prosecution. Smelting companies which buy rare earth ores from illegal miners, or trading companies which trade illegal rare earth products,

[340] Companies involved in the smuggling of rare earth products outside of China can be persecuted under the "smuggling crime" defined by the Criminal Law of People's Republic of China.
[341] Article 96 of the Criminal Law of the People's Republic of China.

therefore may be persecuted with “illegal operation crime”, or may get away with only fines and no jail time. The legal cost of evading Beijing’s regulations is small. For instance, in August 2013 the local court in Qingliu County, Fujian Province charged a rare earth trader buying and selling illegal rare earth ores valued more than a hundred thousand RMB with “illegal operation crime” and sentenced the person to 1 year in prison[342]. With little prospect of ending up with jail sentences and more likely just fines and confiscation of revenues, it is no wonder that companies and individuals would continuously try to evade Beijing’s regulations as soon as a crackdowns or campaign wraps up.

8.6 Industry Development Outcomes

This section analyzes the outcomes of the rare earth industry development since 2008 in industry production and consumption, international trade, market structure, and environmental and social impact. It compares the development results with state goals and mandates in each area.

8.6.1 Domestic Production and Market

8.6.1.1 Mine Production

China continues to be the major supplier of rare earth mine production in the world. China’s reregulation has spurred recent development of junior rare earth products around the world, most notably the re-entry of Molycorp (U.S.) and Lynas (Australia/Malaysia) into the global rare earth mine production. Figure 73 shows the mine production volume of China, the U.S. and the rest of the world reported by the USGS. In 2013, China’s proportion of annual mine production had declined to about 86%

[342] See the court document at http://www.qlfy.com:188/Article/cpws/xsaj/201309/1409.html.

of global production. Yet with Molycorp filing for chapter 11 protection (bankruptcy) in 2015, China's proportion may be increased again in the near future.

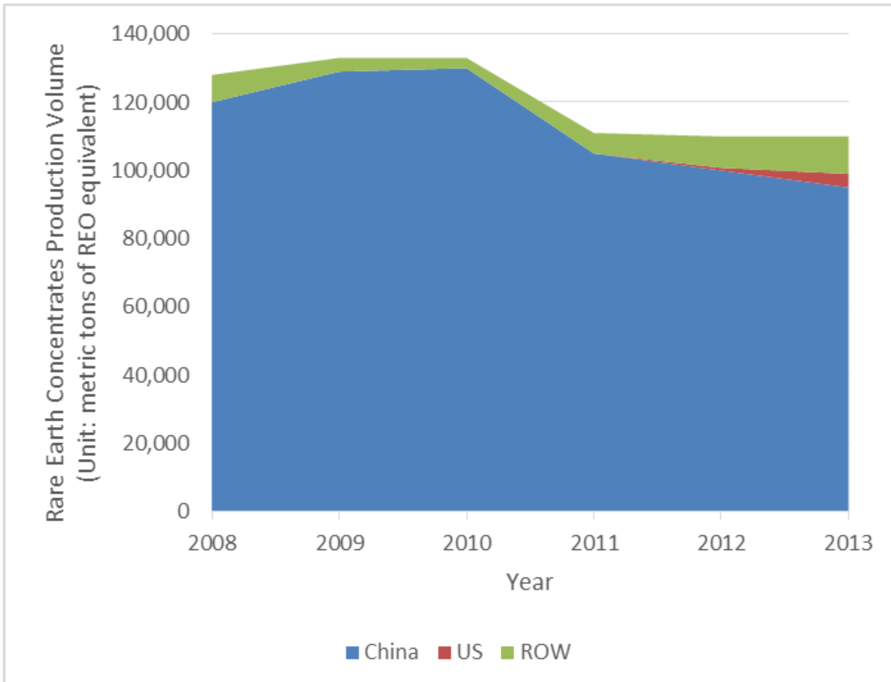

Figure 73 Production Volume of Rare Earth Concentrates by China, U.S. and the Rest of the World (ROW) in 2008-2013[343]

There is a possibility that the USGS overestimates China's production, or the Chinese official statistics underreports the production volume. As shown in Table 8, the official statistics of China's rare earth mine production, reported by the Chinese Ministry of Land and Resources has a large discrepancy compared with the United States Geological Survey's statistics of China's rare earth mine production.

[343] Data Source: the Minerals Yearbooks published by the U.S. Geological Survey from 2008 to 2013.

Table 8 China's Rare Earth Mine Production Reported by MLR (China) and USGS (U.S.) (Unit: metric tons of REO equivalent)[344]

	China's mine production figure reported by MLR	China's mine production figure reported by USGS
2008	125,000	120,000
2009	129,000	129,000
2010	89,259	130,000
2011	84,943	105,000
2012	76,029	100,000
2013	80,423	95,000

On official statistics, the MLR mining quota has successfully brought the mining production under control. Figure 74 compares the mining production statistics with the mining quota released by MLR to assess the effectiveness of the mining quota. The mine production volume reported by Chinese official statistics was much higher than the MLR's production quota in 2008 and 2009, but dropped significantly in 2010 to below the MLR quota and stayed below the MLR quota since 2010. Yet considering the fact that the official production statistics would only count the production volume of mine concentrates from companies allocated with the MLR quota, it is very likely that China's actual production volume is larger than the Chinese officially reported volume. If using

[344] The data reported by the Ministry of Land and Resources is extracted from the *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC. The data reported by the USGS is extracted from the Minerals Yearbooks published by the U.S. Geological Survey from 2008 to 2013.

the production volume data from the USGS, then China's production volume was still higher than the MLR quota from 2010 to 2013, though the difference between the production volume and the quota was substantially reduced over the years.

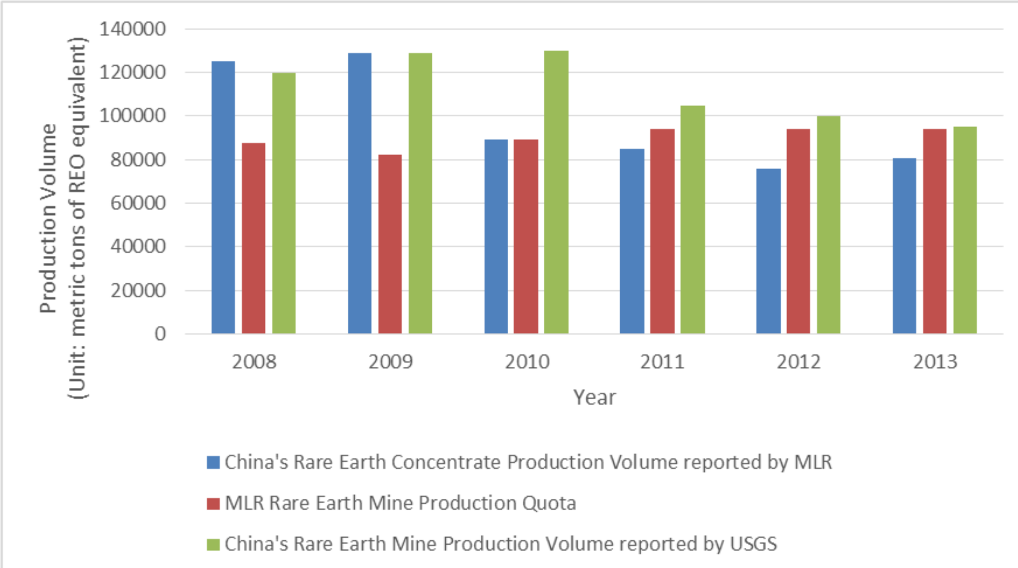

Figure 74 China's Rare Earth Mine Production Compared with MLR Mining Quota (2008-2013)[345]

8.6.1.2 Smelting Production

China continues to be the world's leading producer of rare earth smelting products, yet its attempt at controlling the production volume of rare earth smelting products has not been successful. As Chapter 4 analyzes, due to the lack of sizable competition in rare earth smelting in other countries, even as Molycorp produced rare earth ores from its California mine, the concentrates would have to be sent to China for further processing.

[345] The mine production and mine quota data reported by the Ministry of Land and Resources is extracted from the *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC. The data reported by the USGS is extracted from the Minerals Yearbooks published by the U.S. Geological Survey from 2008 to 2013.

MIIT's annually released production planning has proven to be ineffective in curbing the total volume of production. As Figure 75 shows, China's rare earth smelting production exceeded the MIIT's production plan in 2008, 2009, 2010, 2011 and 2014.

MIIT has primarily blamed the over-plan production on illegal production. According to MIIT, 55 illegal rare earth producers and 22 illegal mines were already shut down in China between 2011 and 2015. (Chang & Hui, 2015) However, MIIT that illegal production still was a big threat to its ability to control production: from September 2014 to May 2015 alone, an estimate of about 12,400 tons of rare earth smelting products were produced illegally (meaning outside of the MIIT plan) in China. (Chang & Hui, 2015)

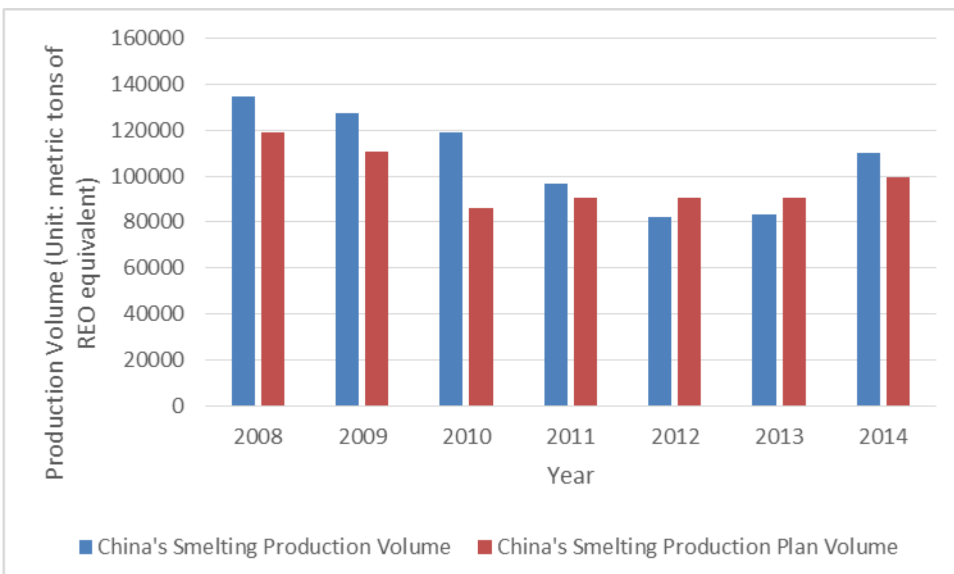

Figure 75 China's Rare Earth Smelting Production Compared with MIIT Smelting Production Plan (2008-2014)[346]

[346] The smelting production data is extracted from *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC. The MIIT smelting production quota data is extracted from relevant quota release policy documents by the MIIT.

The author has found though that the difference between the plan and the reality could be attributed to another additional factor: local provinces in South China had considerable leeway in implementing state plans. For instance, theoretically any firm that receives production and export quota should have passed the Ministry of Environmental Protection (MEP) requirement on environmental emission and the MIIT requirement on industry entry standards. The author conducted a comparison of the list of firms within the rare earth production plan released by the Commissions of Economy and Information Technology of provincial governments of two southern provinces, Guangdong and Jiangxi in 2013, with the list of firms which were eligible under the MEP and MIIT requirements. The comparison showed that four firms in Guangdong and three firms in Jiangxi did not make to either lists by the central government ministries, yet still got production plans from their provincial governments. Bypassing national requirements to give local firms permission to produce render the plans made at the center ineffective.

8.6.1.3 Domestic Market Price Changes

The market price of rare earth products on the Chinese domestic market has reacted strongly to policy changes in the short term. Rare earth prices climbed upward in 2010, and they hit their peak after the State Council released the *Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earth Industry* in May 2011. This short-term abnormally high pricing was primarily driven by the market expectation of stronger state regulations. It was further exacerbated by consumers who went into panic buying and stockpiling and producers and traders who withheld supply to prop up the price. Such high pricing proved to be unsustainable for the domestic downstream users. The market price slowly decreased in 2012 and down to a fairly normal range in 2013. Figure 76 shows the half-yearly data of prices of several low-priced light rare earth oxides from 2008 to 2013. The prices of Lanthanum Oxide and Cerium Oxide, two rare earth oxides used in the largest quantities, increased to a peak price of about 250,000 RMB/ton in June 2011 from a low 10,000-30,000 RMB/ton in June 2008. The prices then slowly reverted to the normal and in December 2013 returned to a low 20,000-30,000 RMB/ton. The prices of Praseodymium Oxide and Neodymium Oxide had much higher increase of almost ten times, from around 100,000 RMB/ton in June 2008 to around 1,000,000-1,200,000 RMB/ton in June 2011. Both prices dropped significantly in 2012 and to a lower level of around 300,000 – 600,000 RMB/ton in 2013. Similar price hikes were also found in higher-priced rare earth oxides. Figure 77 shows that the market price of Europium Oxide, Terbium Oxide and Dysprosium Oxide had increase of almost 7-10 times from June 2008 to June 2011 and gradually returned to the 2008 price levels in 2013.

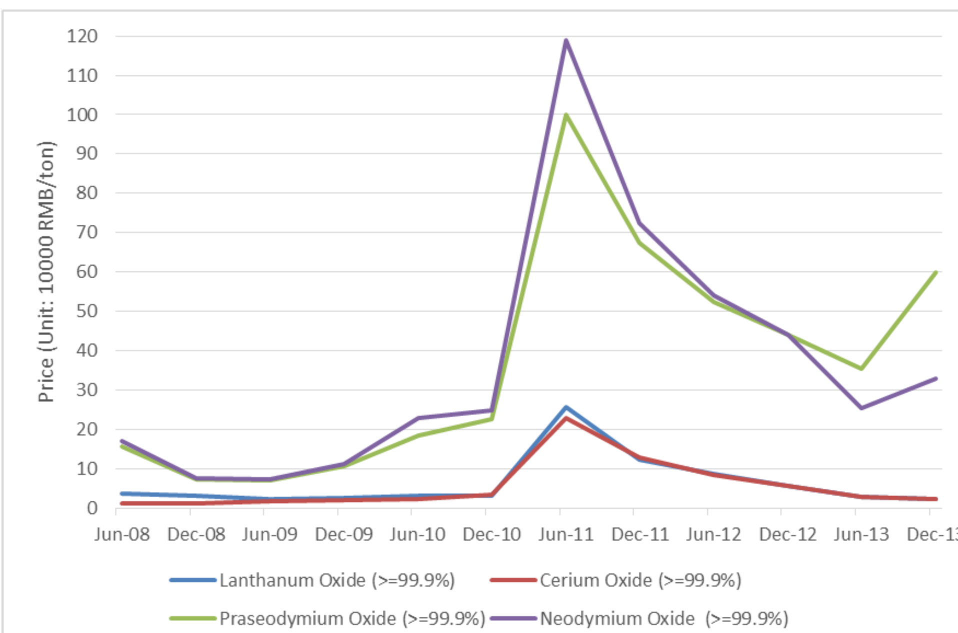

Figure 76 Chinese Domestic Market Price of Lanthanum Oxide, Cerium Oxide, Praseodymium Oxide and Neodymium Oxide (2008-2013)[347]

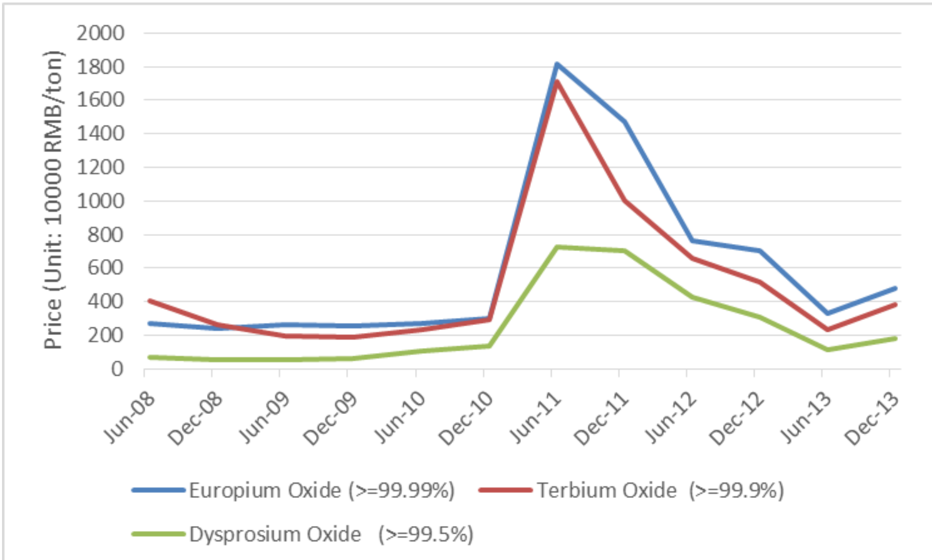

Figure 77 Chinese Domestic Market Price of Europium Oxide, Terbium Oxide and Dysprosium Oxide (2008-2013)[348]

8.6.1.4 Production of Higher-value Products

China's production of higher-value rare earth products, specifically new materials that qualify as part of the strategic and emerging industries (SEI), has increased strongly in this period, although at a less than stellar rate compared to the over-10-times growth in the previous decade of 1998-2007. Figure 78 shows the Chinese consumption of rare earth ores, broken down by consumption by the traditional sectors and consumption by the new material sector. While consumption by traditional sectors has mostly stayed flat

[347] Price data is extracted from the market price database of a Chinese industrial consultancy Baichuan Info.
[348] Price data is extracted from the market price database of a Chinese industrial consultancy Baichuan Info.

from 2008 to 2013, consumption by the new materials sector has shown a strong increase from 35,510 metric tons of REO equivalent to 53,429 metric tons of REO equivalent. Among new materials (including permanent magnets, phosphors, hydrogen storage materials, catalysts and liquid crystal displays), permanent magnets have continued the lead, consuming the largest share of rare earths. As Figure 79 shows, China's production volume of rare earth permanent magnets almost doubled from 2008 to 2013.

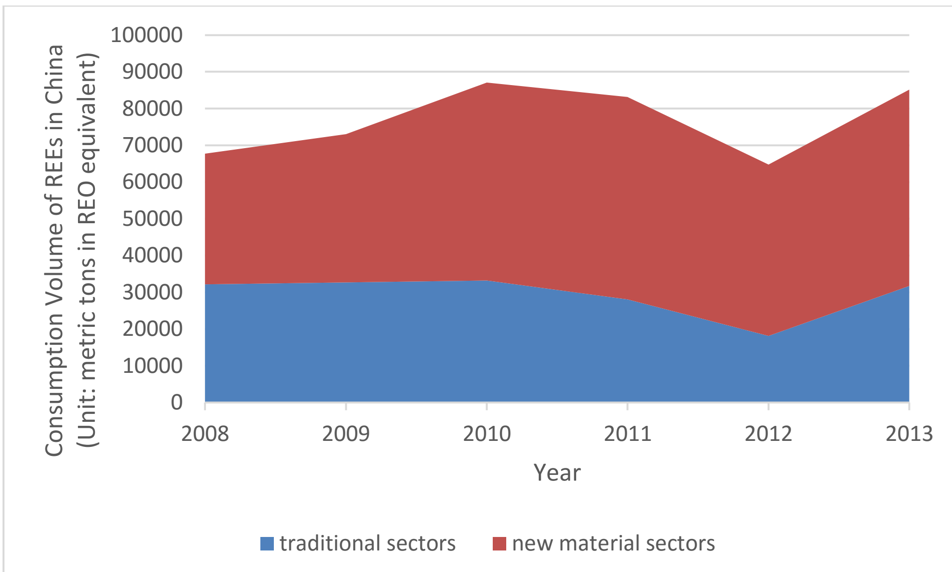

Figure 78 China's Domestic REE Consumption by Traditional and New Materials Sectors[349]

[349] Data is extracted from the *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC.

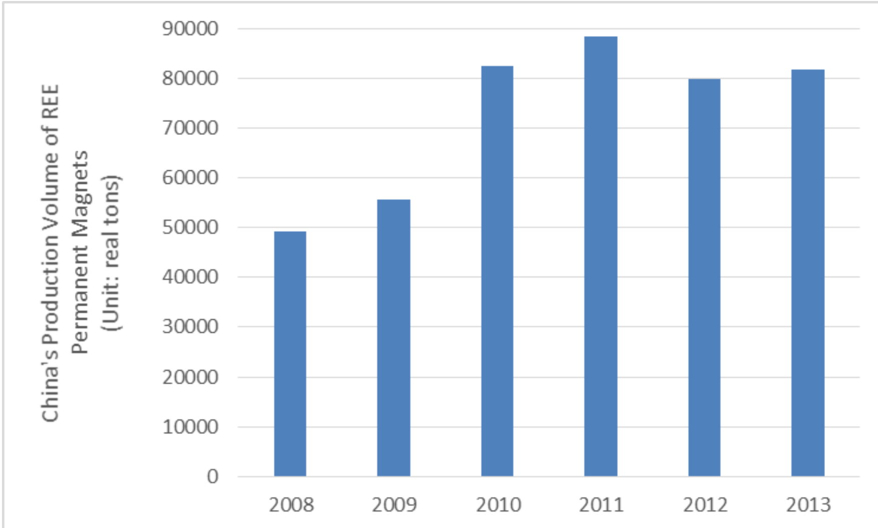

Figure 79 China's Production Volume of Rare Earth Permanent Magnets[350]

8.6.2 International Trade

8.6.2.1 Export Volume and Export Quota

China's rare earth export quota had a drastic cut in 2010 and stayed almost unchanged until 2014. As Figure 80 shows, the reported export volume of rare earth smelting products that were subject to quota restrictions exceeded the export quota in 2008 and 2010, but stayed below the quota in all other years. There are several reasons for the quota not being exhausted. The first reason is that the price hike in 2010-2011 made consumers either delay purchasing from China or use cheaper alternatives, which drove down the export demand. The second reason is that some foreign companies set up joint ventures with Chinese companies to produce products that were not subject to export quota restrictions to be shipped abroad. An example is the South Korean company POSCO, the world's fourth-largest steelmaker. POSCO used to directly import rare earth smelting products from China, but chose to acquire the majority share of a local rare earth

[350] Data is extracted from the *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC.

company called Yongxin Rare Earths in Baotou in 2010; as a subsidiary of POSCO, Yongxin Rare Earths processed the primary rare earth products into materials that would not be subject to the quota restrictions for export to South Korea. The third reason is that the reported export volume could not account for the amount of smuggled rare earth products, which would have put the real export at a higher volume and closer to the quota.

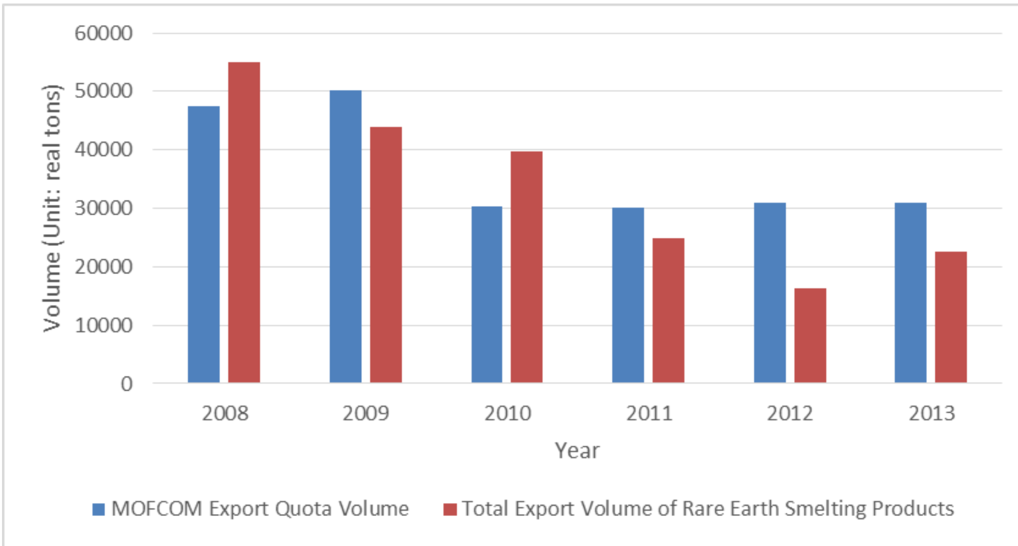

Figure 80 China's Rare Earth Export Volume vs. Export Quota (2008-2013)[351]

8.6.2.2 WTO Dispute against China's Rare Earth Trade Restrictions

The United States, the European Union and Japan brought forward a WTO dispute (DS 431) in 2012 to challenge China's restrictions on exports of rare earths, tungsten and molybdenum[352]. The WTO panel ruled against China in March 2014. China soon appealed the panel reports on all three critical minerals (only on limited aspects of

[351] The export volume data is extracted from *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC. The export quota data is extracted from relevant quota release policy documents by MOFCOM.
[352] For more information about the dispute process and content, see https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm

the reasoning of the panel and certain intermediate findings of the panel report). China's argument for the validity of its export restrictions was based on exceptions to the legal obligations of imposing no non-tariff barriers as laid out in GATT Article XX: "(*b*) necessary to protect human, animal or plant life or health… (g) relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption"[353]. The WTO ruled in August 2014 that it would uphold its rulings against China's restriction over rare earth export. In order to comply with the WTO ruling, China abolished its export quota in January 2015 (PRC Ministry of Commerce, 2014) and tariff in May 2015 (PRC Ministry of Finance, 2015), however the export of rare earth products would still be limited to companies with active export licenses granted by MOFCOM each year.

When the author conducted the field work in China in 2013, the dispute was still under WTO panel review, yet most industry observers that the author had spoken to in China had correctly predicted that China would lose the case and would in turn substitute its export restrictions with other kinds of control measures. As the previous section on industry-specific policies analyzed, export control was viewed as a convenient tool that Beijing could utilize to influence company behavior, and export control measures were implemented by Beijing along with other domestic policies strengthening the state's control over the market. China previously lost a WTO dispute concerning its export restrictions on various raw materials, the DS394 *China – Raw Materials* case in 2012[354],

[353] For more information about GATT Article XX and the exceptions to the legal obligations (where countries can impose trade restrictions), see https://www.wto.org/english/res_e/booksp_e/analytic_index_e/gatt1994_07_e.htm
[354] This dispute concerns certain measures imposed by China affecting the exportation of certain forms of bauxite, coke, fluorspar, magnesium, manganese, silicon carbide, silicon

while claiming validity of the restrictions on the exceptions in GATT Article XX. Because of this precedent, both policy makers and industry experts in China were prepared for a similar outcome in the rare earth case. In addition, Beijing also saw the limit of export quota as an effective constraining tool: as Figure 80 showed, the export quota from 2011 exceeded the officially reported export volume every year, thus scraping the export quota on paper would not make much difference.

With the expection that the export quota and tariff would be abolished, the state sought to compensate through strengthening measures to control domestic production. The Vice Secretary General of the CSRE Zhang Anwen wrote that “we should strengthen the two (domestic) production plans to prevent extra-quota mining and smelting; wage strong campaigns to target illegal mining and smelting; implement with force the laws and regulations on resource conservation, environmental protection and ecological restoration; achieve higher concentration in the market structure; aggressively target smuggling” (Zhang, 2014) Immediately after China scraped its export quota and tariff to comply with WTO ruling, the State Administration of Taxation announced new taxation on all rare earth products (not just exports) starting May 2015. The taxation on rare earth products was changed from a volume-based resource fee to a gross-sales-based resource tax; thus the higher-valued, less-abundant HREEs would be taxed at a much higher rate by volume. Beijing introduced 7.5%-11.5% resource tax on the gross sales of light rare earth ores and primary products (calculated into ore gross sales) and 27% resource tax on the gross sales of the more valuable heavy rare earth ores and primary products (calculated into ore gross sales). (PRC Ministry of Finance & State Administration of

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metal, yellow phosphorous, and zinc. For more information about the dispute process and content, see https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds394_e.htm

Taxation, 2015) This new resource tax essentially offset the gains to foreign buyers of rare earth products that would be brought by the abolishment of tariff (15-25%).

8.6.2.3 Export of Higher-value Products

China's export of higher-value rare earth products continued to have strong increase in volume. Take permanent magnets as an example, which is the category of new materials that consumes the largest volume of rare earth products. As Figure 81 shows, China's export of rare earth permanent magnets almost doubled in volume between 2008 and 2013. Following the price swings of the rare earth smelting products on the domestic market, the export value of the permanent magnets hiked to almost five times of 2008 levels in 2011, but gradually reverted to a lower level in 2013 (shown in Figure 82). The average price of export of permanent magnets had an increase from 44.98 USD/kg in 2008 to 111 USD/kg in 2011, then reverted back to a lower 71.38 USD/kg in 2013.

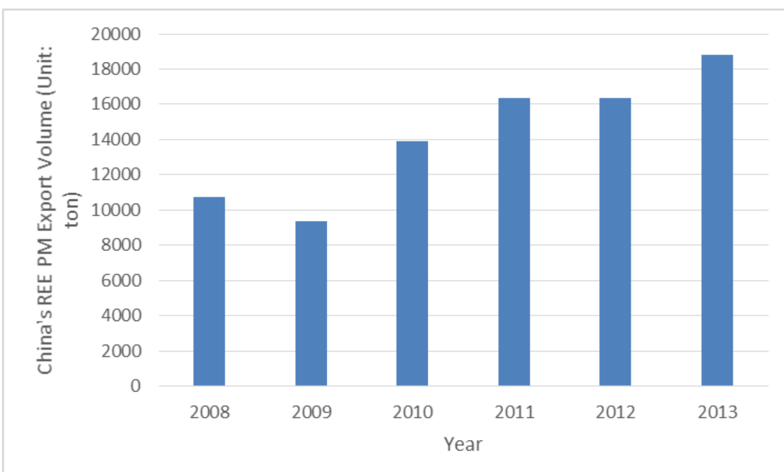

Figure 81 China's Export Volume of REE Permanent Magnets (2008-2013)[355]

[355] Data is extracted from extracted from *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC.

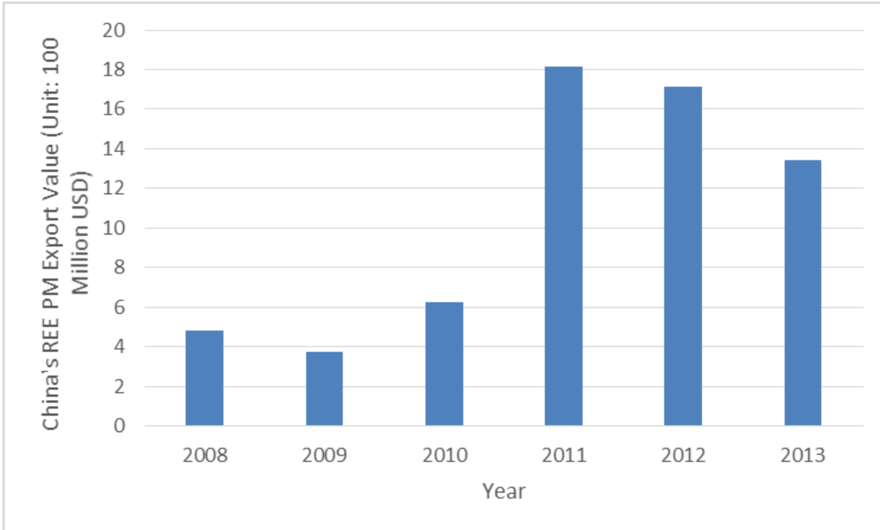

Figure 82 China's REE Permanent Magnet Export Value (2008-2013)[356]

In the meantime, intellectual property regarding the permanent magnets, crucial to the availability of the export market, has become a battle ground between Hitachi and Chinese magnet producers. On August 17, 2012, Hitachi Metals announced a formal complaint with the United States International Trade Commission (ITC) against 29 manufacturers and importers of sintered NdFeB magnets and products containing sintered NdFeB magnets, including three Chinese manufacturers. Hitachi listed the violation of four "processing" patents (6,461,565; 6,491,765; 6,527,874 and 6,537,385) filed in 2001-02. Hitachi sought exclusion orders prohibiting the entry of magnets and products containing those magnets produced by these companies into the U.S. (Hitachi, 2012) The complaint ended through a settlement between Hitachi and the accused manufacturers, by the latter paying a large sum of money to gain patent licensing. In response to Hitachi's complaint, a dozen Chinese companies sued Hitachi Metals for holding invalid extension

[356] Data is extracted from extracted from *Annual Reviews of Chinese Rare Earth Industry* from 2008 to 2013, published by the Department of Industry Coordination at NDRC.

of patents, claiming that their manufacturing process uses indigenous technologies that do not infringe Hitachi's processing patents. The lawsuit is currently ongoing, and it will likely result in further granting of Hitachi's licenses to more Chinese manufacturers.

A further consequence of the dispute over permanent magnet technology protection between China and Japan is that proposed Sino-Japan joint ventures involving permanent magnets have recently been subject to much stricter scrutiny due to new export control measures from METI. There are existing Sino-Japan joint ventures in China producing permanent magnets for end production in Japan. For instance, Japanese electronics firm Showa Denko has two subsidiaries in China, one in Baotou, Inner Mongolia (LREE production region) and one in Jiangxi Province (HREE production region). The local Showa Denko subsidiaries have Showa Denko as the majority shareholder and Chinese rare earth producers as the minority shareholder, and they primarily employ Chinese workers and managers. They buy rare earth products directly from local producers, and they produce rare earth materials which are manufactured in Japan into electric motors for cars and hard disks. Yet in July 2012 the Japanese Ministry of Economy, Technology and Industry (METI) implemented an amendment restricting exports of manufacturing facilities and components for products that could have dual use applications, including high-performance magnets, the equipment to make them and the related components. (Nikkei, 2013) Japanese firms planning to set up joint ventures with foreign producers would need to provide proof that the technology being transferred in export of manufacturing will not be used for military purposes. This has led to delays in several planned Sino-Japan joint venture projects (including a planned joint venture led by TDK to produce high-function magnets in China using Chinese rare earth supply for hybrid vehicles). After several rounds of consultation with METI, TDK finally was allowed in 2014 to proceed with the plan for a joint venture with Guangdong Rising Non-ferrous Metals. (Nikkei, 2014)

8.6.3 Market Structure

As the previous section shows, Beijing's restructuring plan to consolidate the rare earth industry into 2-3 state-owned supersized conglomerates did not materialize. Major Chinese mining companies have engaged in fierce competition for acquiring resources and companies. If they are selected as major industry conglomerates in Beijing's restructuring plan, they would be the few companies able to dominate China's rare earth mining and smelting production in the future. The industry restructuring is still an ongoing process, as companies have been going through negotiation talks for mergers and acquisitions. Most recently in January 2015, Beijing picked six companies as the major rare earth companies to be granted the rare earth smelting production quota from MIIT. As Figure 83 shows, the selection was a mix of central SOEs and local provincial/prefectural SOEs, showing a compromise of center/local government interests regarding the control over the industry. Two central SOEs under the supervision of SASAC in Beijing, China Minmetals and China Aluminum, were selected into the list. As the previous chapter demonstrates, the failure of the industry consolidation in 2002-2005 was partly due to the central SOEs' lack of control over upstream mining resources. Besides the existing smelting production capabilities, both of the two central SOEs have acquired new mining licenses for rare earth projects, thus boosting their control of upstream resources. Two other central SOE that were spin-offs from the Big-Three rare earth trading SOEs of the 1990s, China Non-ferrous Mining Group[357] and Sino Steel Corporation[358], were long rumored to be picked by Beijing as would-be conglomerates, but ended up not obtaining any mining licenses and not on the list supplied by the MIIT in 2015. Four local SOEs were selected, each backed by a local provincial/prefecture government. These local SOEs have already gained control over some or all local rare earth mining licenses (hence upstream resources) and have acquired additional companies or resources for the desired status of supersized conglomerates. Below is the detailed description of each major company's expansion in the rare earth industry, leading to their selection by Beijing for industry restructuring.

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[357] As seen in the previous chapter, China Non-ferrous Mining Group, known for short as China Non-ferrous Metals, was built after the 1998 State Council Reform from subsidiary units of China National Non-ferrous Metals Industry Corporation's overseas construction operations, and thus did not have any rare earth mining licenses or mining subsidiaries.

[358] As seen in the previous chapter, Sino Steel Corporation's trading subsidiary, Sinosteel Trading Company, was originally China Metallurgical Import & Export Company, one of the three SOEs eligible for rare earth export in the 1990s before the 1998 State Council Reform.

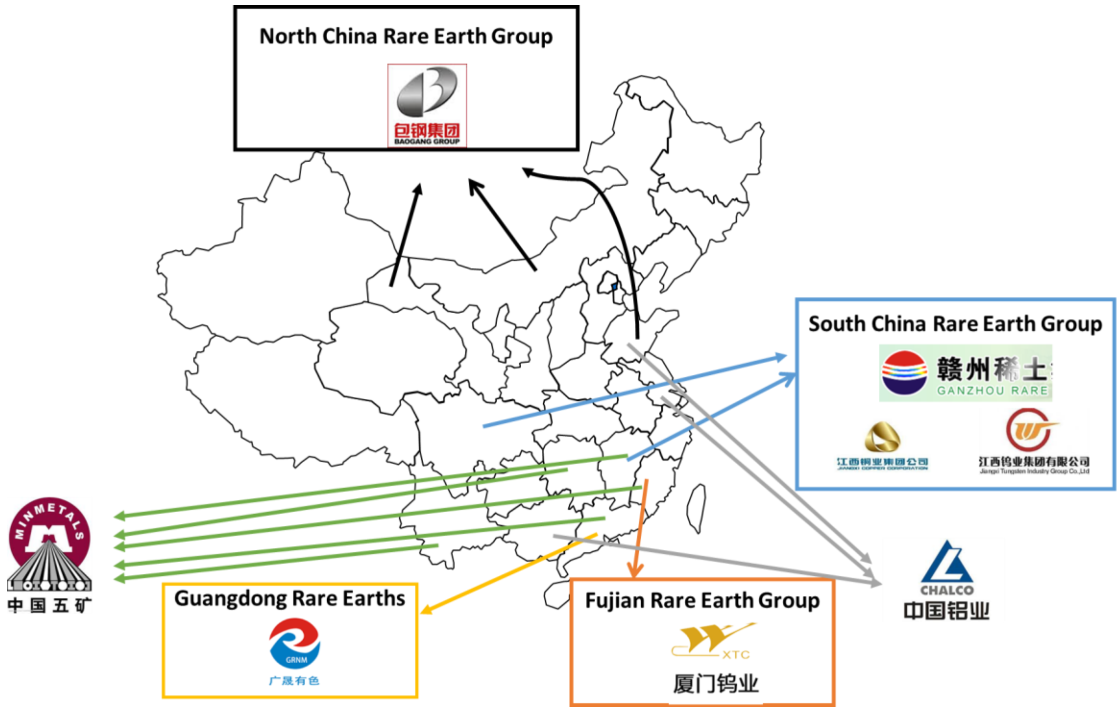

Figure 83 Six Major State-owned Enterprises Selected for Rare Earth Industry Restructuring in 2015

1) **China Minmetals (中国五矿)**, a central SOE which has its roots in the rare earth industry since the early years of China's economic reform, has emerged as one of Beijing's strongly favored choices. While China Minmetals lost its control over mining licenses to Ganzhou Provincial Government in the aftermath of the 1998 State Council Reform, it has in the past few years acquired new licenses in other regions. China Minmetals currently holds three mining licenses (one in Hunan Province, one in Fujian Province and one in Yunnan Province) and one exploration license (in Guangdong Province). China Minmetals is also the parent company of eight rare earth smelting companies in Jiangxi Province and Guangdong Province in South China.

2) **Aluminum Corporation of China (中国铝业)**, CHALCO for short, was the central SOE that suffered complete defeat in its attempt to consolidate the rare earth industry in 2002-2005. Like China Minmetals, CHALCO has also managed a comeback. It currently controls five rare earth mining licenses through acquiring six rare earth mines around the country and acquiring all rare earth smelting companies in Shaanxi Province and Guangxi Province (where rare earth resources have recently been identified). China Aluminum is also the majority shareholder of several rare earth smelting companies in Jiangsu Province, Shandong Province and Sichuan Province.

3) **Baotou Steel (包钢股份)**, a provincial SOE whose control was transferred from Beijing to the Inner Mongolia government in the 1998 State Council Reform, remains the undisputed choice for Beijing to consolidate the rare earth industry in North China. Baotou Steel is the parent company of Baotou Steel Rare Earths, which controls the Baiyun-ebo Mine. To further expand its control over the industry, Baotou Steel has established a rare earth conglomerate subsidiary named **North China Rare Earth Group** （中国北方稀土（集团）高科技股份有限公司）[359]. As the majority shareholder of this conglomerate, Baotou Steel has acquired dozens of other companies to boost its market share and branch into smelting and downstream production. It has signed acquisitions deals with all other rare earth smelting companies in Inner Mongolia, as well as with Gansu Rare Earths, a major rare earth smelting company in Gansu Province in North China.

[359] For a list of companies currently within the conglomerate North China Rare Earth Group, see its website at http://www.reht.com/sitefiles/services/cms/page.aspx?s=1&n=9.

4) **Ganzhou Rare Earths (赣州稀土)**, a prefectural SOE controlled by the prefecture SASAC of Ganzhou Prefecture Government, won the battle against central SOEs and other local SOEs to lead industry restructuring in Jiangxi Province. As a local SOE championed by the prefectural government, Ganzhou Rare Earths is the holder of 43 rare earth mining licenses (out of a total of 45 mining licenses) in Ganzhou Prefecture and has acquired almost all rare earth smelting companies in the prefecture. In order to counter the acquisition efforts of central SOEs, Ganzhou Rare Earths joined forces with two other provincial SOEs, Jiangxi Copper (江西铜业) and Jiangxi Tungsten （江钨集团） to establish a rare earth conglomerate named **South China Rare Earth Group** **（中国南方稀土集团有限公司）**in 2015. The registered capital of South China Rare Earth Group was 1 trillion RMB, of which 60% came from Ganzhou Rare Earths, 35% from Jiangxi Copper and 5% from Jiangxi Tungsten. (Huang, 2016) Besides its stronghold over the home base of Jiangxi Province, this new conglomerate also controls rare earth mining resources in Sichuan Province in southwest China. Jiangxi Copper, the minority shareholder, won a high-price bid against China Aluminum in landing a deal with the Sichuan Provincial Government to jointly develop rare earth resources. Jiangxi Copper has acquired rare earth mining licenses in Sichuan Province and acquired most of the local rare earth smelting companies in Sichuan Province.

5) **Guangdong Rising Nonferrous Metals Company (广晟有色）**, a provincial SOE in Guangdong Province, was chosen by Guangdong provincial government as the local SOE contender for the restructuring of the rare earth industry. The company’s controlling shareholder is Guangdong Rising Assets Management Company, directly

controlled by the provincial SASAC of Guangdong Provincial Government. In 2012 Guangdong Rising Nonferrous Metals Company established a rare earth company named **Guangdong Rare Earths (广东稀土）** with registered capital of 1 trillion RMB. Guangdong Rare Earths now controls three rare earth mining licenses in Guangdong Province (which has four in total). To boost its market size in the midstream and downstream of the supply chain, Guangdong Rare Earths, backed by the provincial government, would acquire 12 earth smelting and applications producing companies in Guangdong Province, making it the monopolizing company for the rare earth industry in Guangdong Province. It also plans to acquire additional nine rare earth companies in other provinces in China[360].

6) **Xiamen Tungsten (厦门钨业)**, an SOE in Fujian Province, became the vehicle of Fujian Provincial Government to lead the restructuring process. As the previous chapter analyzed, apart from one mining license held by the central SOE China Minmetals, rare earth mining licenses in Fujian Province were controlled by counties in a decentralized manner. As Beijing pushed forward its industry restructuring agenda, Fujian Provincial Government sought to consolidate the control over the rare earth resources and companies in its own hands. Xiamen Tungsten is the largest producer of tungsten in the world. Its two major shareholders before 2011 were Fujian Nonferrous Group (33.6%) and China Minmetals (20.58%). Fujian Nonferrous Group is a provincial asset management company wholly owned by the Fujian Provincial Government to manage state assets in the nonferrous metal industries. As a

[360] For more information, see the company website at http://www.gdrising.com.cn/index.php?m=content&c=index&a=show&catid=28&id=422.

newcomer to the rare earth industry, Xiamen Tungsten only started investing in rare earth production in 2006. In 2012 Fujian Provincial Government instructed Fujian Nonferrous Group to rename one of its subsidiaries to specifically **Fujian Rare Earth Group (福建稀土集团)**. Fujian Rare Earth Group got all share owned by its parent company through free transfer and bought additional share of Xiamen Tungsten to increase its share percentage to 34.28%. Meanwhile China Minmetal's share percentage dropped to 15.58%. Thus Xiamen Tungsten became an SOE that the provincial government could exert majority control. By 2014 Xiamen Tungsten has acquired all rare earth mining licenses in Fujian Province except the one held by China Minmetals.

8.6.4 Environmental and Social Impact

Beijing's campaign to clean up the pollution in the rare earth industry has yielded notable progress. Strong institutional incentives to prioritize environmental protection, such as requiring environmental compliance in production and export quota allocation and funding to local governments for environmental management, have prompted companies and local governments to invest in environmental treatment. For instance, the Baiyun-ebo mining region was selected into the 40 "Model Bases of Comprehensive Utilization of Mining Resources" designated by Beijing. Baotou Steel was awarded by both the central and local governments funding totaling more than 6 billion RMB to lessen the danger of the "tickling bomb" tailings lake which stores waste including radioactive thorium. The funding would be devoted to multiple measures to prevent additional damage, including relocating local residents, treating solid waste landfills, relocating production lines, treating waste water, restoring grasslands and nearby ecological environment. (Hu, 2013) The rare earth smelting plants of Baotou Steel Rare Earths also went through an upgrading of the waste treatment technologies, which enabled them to stop dumping new waste water into the tailings lake in 2014. (Fan & Qing, 2013) Beijing's production planning, industry restructuring phasing out small producers, as well as crackdowns on illegal mining and smuggling also helped to decrease the pollution from illegal operators and companies using backward technologies. However, more innovation and adoption of environmentally-friendly production technologies is necessary to ensure long-term sustainability of production. In Gannan-Yuebei region for instance, the in-situ leaching method to mine rare earths from ores, which has gradually been adopted over dump leaching and tank leaching methods that has led to stripped mountains, still produces damage including waste water, waste residues and the possibility of dangerous landslides. Better treatment and improvement to existing technology would be needed to decrease the environmental impact.

The devastation of environment after decades of excessive rare earth mining is impossible to treat in a short time. In Baotou in North China, as of July 2013, waste water discharge in the city still did not meet the Chinese state standard of waste water discharge[361]. The treatment of the tailings lake has mostly been focusing on lessening the danger to local residents and ecological environment rather than completely eradicating the waste. Baotou Steel estimates that the discarded ores and waste water dumped into the tailings lake since the 1950s now contains REEs and thorium valued around 1 billion USD. Thus the company has been faced with the difficult task of both extracting the valuable resources and treating the environmental damage associated with them. Baotou

[361] Author interview with local businessmen in Baotou Prefecture in July 2013.

Steel has missed qualifying for rare earth export quota due to failing environmental inspection twice, once for the second batch quota of 2011 and once for the second batch quota of 2012. Both times the company was granted supplementary quota later after implementing further treatment measures. In 2013 Baotou Steel devoted more than 2 billion RMB to pollution treatment, but still missed qualifying for the export quota allocation for the first batch of 2014. The company was given provisional export quota later, yet the treatment of the tailings lake remains, as the head of the BRIRE Yang Zhanfeng argues, “a complicated and difficult issue”. (Wang, 2014) Similarly in Ganzhou Prefecture in South China, the legacy of environmental degradation is gigantic. An estimate conducted by Ganzhou Prefecture required roughly 38 billion RMB to fund the restoration of the past mining areas back into an ecologically sustainable landscape, thus the treatment of waste and stripped land would require more money than the revenues it generates from the industry. Ganzhou Prefecture government further estimated that the treatment of existing damage to the ground vegetation due to rare earth mining would require at least 70 years, not counting the treatment for new damage to the ground vegetation due to continued mining[362]. It should be noted though that the exact amount of funding required for environmental treatment of Ganzhou Prefecture is still open to debate among academics in China; some have argued that the local government tends to overestimate treatment funding required in order to get more funding from Beijing, and the actual cost would likely be less with the upgrading of production technologies[363]. Nevertheless, environmental treatment remains costly and restoration is unlikely to be achieved until several decades in the future.

[362] Author interview with university researchers in Ganzhou Prefecture in July 2013.
[363] Author interview with an officer of the China Rare Earth Society in May 2013.

8.7 Reregulation with Losers

While international observers tend to look at China as one big entity that stands to benefit from its REE export restrictions at the expense of the importing countries, this view overlooks the mixed effects Beijing's campaign has created within the rare earth industry in China. A blanket policy campaign covering an entire industry that produces many different kinds of products is bound to produce negative effects for some industry actors. Through fieldwork visits with businesses, the author has found the following cases where Beijing's regulations led to undesirable effects in implementation.

1) One private rare earth smelting company in North China complained that the local environmental inspections followed a rigid measure of environmental treatment facilities. Thus although the company had already installed treatment facilities and discharged waste in compliance with the waste discharge regulations, it had to buy additional environmental treatment equipment to satisfy local environmental inspections.

2) Some companies in South China complained about the fixed standard for market entry concerning minimum production capacity applied to all producers to phase out the smaller companies. MIIT's minimum production capacity for market entry standard is measured in volume of production, without taking into account the value of production or the amount of market demand. Thus some companies producing specific higher-value products at low volumes would not fit the MIIT standard, and they had to work around the rules with the local government to continue production.

3) One company producing a variety of rare earth applications in South China complained that some of its products had been wrongly categorized by the customs, thus

its exports had been taxed at an unfairly high tariff rate. The company disputed about the unfair categorization and was in the process of working out the corrections.

4) Several private companies in North China complained of more lenient implementation of policies for the SOEs in the same region. State-owned enterprises received better tax treatment and more funding compared to private enterprises. State-owned enterprises were also given opportunities to receive provisional production or export quota after failing environmental inspections, and they were able to continue receiving production or export quota until meeting market entry standards.

5) Several domestic private companies complained that joint ventures that foreign companies formed with domestic SOEs received unfair advantage over wholly-owned domestic companies. Joint ventures, based on their status as foreign-invested entities, could receive preferential export tax treatment, lower land rents and various other benefits from the local government. Although the local government rhetoric justifying the treatment was that the foreign-invested joint ventures could bring in advanced technologies, the local domestic companies posit that the joint ventures primarily served as tools for foreign companies to circumvent export quota restrictions: they export rare earth products that went through very little further processing from primary products, but enough to be not categorized among those restricted by the General Customs.

6) Downstream and down-downstream companies were strongly affected by the rare earth price fluctuations between 2010 and 2013. Compared to the upstream mining dominated by the central and local SOEs, downstream companies such as permanent magnet producers and down-downstream companies such as electric motor producers were primarily driven by private capital. Such companies do not have the access to

government funding or bank loans as the SOEs do, and they primarily compete by offering comparable products with lower costs. The fluctuation of raw materials costs led to some companies unable to keep stable cash flow and going bankrupt.

8.8 Conclusion

This chapter analyzes the current Chinese state reregulation of the rare earth industry from 2008. In this post-global-financial-crisis period, the central government has continued to steer the national economy on a grand scale through massive stimulus package to boost domestic demand, sectoral restructuring to increase SOE consolidation, and innovation promotion through promoting strategic and emerging industries. In the rare earth industry, Beijing's reregulation goals are sustainable production and environmental protection, technology upgrading to fulfill domestic demand, securing resource advantage to facilitate downstream development, and breaking the domestic applications' barrier to international markets. The central government has introduced new rules and revised old rules on production quota, taxation and licensing, market entry, export quota, tariff and export licensing. Beijing has led numerous funding schemes on promoting the upgrading of industry technologies. Beijing's nationwide campaign of industry restructuring, though dragging far behind its original schedule, has narrowed down industry consolidation into several major central SOEs and local SOEs. In local production regions, Beijing has conducted almost annual campaigns cracking down illegal mining and smuggling. Beijing has strengthened its environmental inspections as well as its institutional incentives for companies to invest in pollution control and environmental compliance.

Political institutional changes have also occurred and influenced the state's ability to implement the policies successfully. The increased inter-ministry policy coordination within the State Council, cross-regional cooperation in law enforcement, and changes to the local cadre evaluation system have contributed to better enforcement of Beijing's reregulation policies. However, greater institutional changes are still needed to empower specific local agencies such as environmental protection bureaus to enforce central policies, to strengthen the inspection of local cadres independent of the influence of local governments, and to uphold the legal penalty for criminal behavior.

The alleged halt of rare earth export halt to Japan after the Senkaku/Diaoyu Island incident in the second half of 2010 was an event that drew worldwide attention to China's policy changes. Yet as this chapter demonstrates, the alleged embargo cannot be substantiated based on the official Japanese import data available. The reported "delay" of rare earth exports to Japan reported by the Japanese trading sources was likely the result of Beijing's ongoing domestic policy campaigns which met up against a drastically cut half-year export quota.

The result of Beijing's reregulation policies in industry development was a mix of successes and failures. In production, China has continued to be the world's major rare earth producer and smelter. Beijing's efforts to control production volume through quota planning has been not so successful, as smelting production was higher than the plan. Instead of leading to a more stable market conducive to long-term growth, Beijing's policy campaigns prompted drastic market price changes in 2010-2013, with domestic prices peaking in mid-2011 for the different kinds of rare earth oxides at prices roughly 7-20 times of pre-2010 levels. The price shock not only led to market speculation and instability, but also affected downstream production to the point of inducing bankruptcies. In terms of technology upgrading, China's rare earth consumption by the new materials sectors has shown a strong increase compared to the relatively flat consumption by traditional sectors, showing a continued strong trend towards upgrading the value chain. In export, China's export volume has stayed below its export quota since 2011, before it was required to scrap the quota and tariff restrictions to comply with WTO ruling in 2015. China's export of higher-value rare earth products have continued to increase, yet many domestic permanent magnet producers have still been locked in a patent-induced market entry battle with Hitachi. METI's export control on high-value permanent magnets also led to delays in planned Sino-Japan joint ventures producing higher-value permanent magnets in China. In terms of market structure, Beijing's original plan to consolidate the industry into 2-3 conglomerates in two years suffered significant local pushback, and restructuring has dragged on and is still ongoing. The restructuring process has become a gruesome battle amongst central SOEs, local SOEs and local private companies for survival and the chance to become Beijing's pick. Control of mining resources through mining licenses proved to be crucial in the battle for dominance. Two central SOEs and four local SOEs were selected into the MIIT's tentative list of corporations allowed to receive production quota. In environmental protection, Beijing's funding schemes and institutional rewards have resulted in new and larger initiatives by companies and local governments to treat existing pollution and upgrading technologies of production. Yet the pollution legacy is so gigantic that it is impossible to achieve much progress in ecological restoration in the short term. The author has further uncovered instances where the implementation of Beijing's regulations resulted in excessive regulatory requirements, evasion of government control through regulatory loopholes, and unequal treatment of companies, thus hurting specific local companies. To summarize, Beijing's reregulation campaign has seen a mix of success and failure; its capacity to promote industrial change in the rare earth sector to satisfy its goals has shown to be not so strong as many outside of China would imagine.

CHAPTER 9 EXPLAINING REGIONAL VARIATION IN STATE CAPACITY OF REREGULATION

As the previous chapters show, Beijing has long had trouble enforcing its reregulation policies at the local level. Local governments and market actors were not all pleased to follow the central government development agendas. At the national level, political and legal institutional factors in each period have influenced the extent to which the state was able to effectively implement its policies and achieve its goals. At the subnational level, compared to North China (with Baiyun-ebo as its major mining region), South China (with Gannan-Yuebei as its major mining region) has had a more serious problem of clashing between the central government and local stakeholders. This chapter analyzes the reasons behind the subnational disparity in Beijing's capacity to enforce its campaigns. Why have local stakeholders been pushing back more forcefully against Beijing's policies in South China compared to North China? The answer involves three factors related to local contexts, including the geographical concentration of local mining deposits, the technology intensity of local mining production and the local market concentration of mining licenses.

9.1 Geographical Concentration of Local Mining Deposits

First and foremost, geographical concentration of mining deposit is a local-level independent variable influencing the state capacity to impose effective rules. Lower geographical concentration of mining deposits leads to a greater dispersion of mining operations in many lower-level jurisdictions, as well as a greater technical difficulty in implementing effective snap inspections. This leads to lower chance of compliance with state mandates.

The mineral deposits in Baiyun-Ebo region in North China is the largest rare earth deposit in volume in the world; such a large deposit is concentrated within the plateau mining region on the Ulanqab Prairie close to the city of Baotou and administratively falls within the Baiyun-ebo District. On the other hand, the mineral deposits in Gannan-Yuebei region in South China are fairly dispersed in small volumes throughout the mountainous areas spreading across many villages across the borders of three provinces.

The geographical dispersion of mineral deposits in South China led to a naturally greater dispersion of mining sites producing small numbers of primary ores in many lower-level juridictions (villages and counties). Over time these grew into many local mining operations with close ties to the respective local lower-level governments. As Chapter 6 and Chapter 7 explains, while the mineral resources theoretically belong to the Chinese state, the local rural residents have the right to use the forests and the right to use the land. As China started embracing the market economy in the 1980s and institutionalized incentivized rare earth production and export, mining started booming rapidly across many villages in Gannan-Yuebei region. Local village or county cadres, who usually would have a final say on land use and forest use, would attract private capital from wealthy businessmen in richer provinces, or provide starting money themselves or pool money from local businesses. The money would be used to buy out the land and forest use rights of the land where mining would take place and pay for equipment and operating costs for producing primary ores. Some local villagers were then hired by the business investors or village cadres to do the actual work using tank leaching, dump leaching or in-situ leaching method. The products were stamped with invoices from the local subsidiary of the central SOEs (before the 1998 State Council reform splitting the major central bureaucratic system) or from the local provincial/prefecture SOEs (after the 1998 State Council reform and subsequent local consolidation of mining assets) and able to be sold on the market. Thus there was a considerable degree of local autonomy in the on-the-ground operation. The mining operations also have closer ties with the local cadres who would provide regulatory permission and oversight for mining but also might depend on mining for providing both personal benefits (such as financial returns) and public benefits (such as employment of local workers and revenue for the county/village government). While Beijing imposes control over rare earth production and export, the local businessmen running the artisanal mines could still continue the operation if they could bribe local county or village regulators into covering for them. They might also bribe local villagers to prevent them from tipping off the operations to the inspectors dispatched from higher-level governments.

The local mountainous geography of the mining region in South China also presents a greater difficulty for effective snap inspections. Prior to the adoption of satellite imaging and other advanced technologies for digital surveillance, local cadres working in mineral resource management bureaus mostly accessed the mining sites by foot (see the example of such geography in a mining site in Ganzhou Prefecture in Figure 84). This made it easier for the illegal mining operators to cover their tracks in anticipation of inspections. As one local resident remarked, “once the inspector teams arrived in the county, the miners would get word of inspectors coming and would promptly stop the operation and wait for the inspection to pass."[364]

Figure 84 Photo of a Mining Site in Ganzhou Prefecture

9.2 Technology Intensity of Local Mining Production

The second local-level variable influencing the state capacity to implement its policies concerns the technology intensity of local mining production. The technology intensity of mining is related to the geological conditions of the deposit. Lower technology intensity of local mining production allows for more extralegal production and artisanal mining difficult to control by the state, thus leading to lower enforcement of state mandates.

The rare earth deposits in South China's Gannan-Yuebei region are ionic adsorption clay deposits which occur in a weathered profile and very close to the earth

[364] Author interviews with local residents in Ganzhou Prefecture in July 2013.

surface. Therefore, such mineral deposits can be easily extracted from the underground without much technical expertise. During fieldwork the author found that the local miners could just use fertilizers sold on the market to make solutions to extract primary ores from the ground on the mountains, even simply using their backyard or nearby pools. This low technology intensity of mining production in South China has created a higher propensity for artisanal mining to flourish and operate within grey areas of black markets outside of state control. It has also contributed to lower cost of market entry for local businesses and has lured investors looking to make some quick cash even while risking breaking the rules. As a result, illegal mining and smuggling became more prevalent. While the recent crackdown campaigns could temporarily halt the illegal activities, artisanal mining would be easier to resume after crackdown campaign dies down.

On the other hand, the basternite rare earth deposit which coexist with iron and radioactive elements including Thorium in Baiyun-ebo region requires relatively higher technology intensity of local mining production in North China. This leads to lower chances of such short-term, small-scale and artisanal mining to grow and evade Beijing's regulation. The illegal production and smuggling in Baiyun-ebo region has been more in the style of "insider jobs": employees of Baotou Steel would allow extra production to be flown into the black market or bought by smelting producers with unfulfilled smelting quotas[365].

9.3 Local Market Concentration of Mining Licenses

The third subnational-level variable of local context influencing the state capacity to effectively implement its goals and policies is the market concentration of mining

[365] Author interview with local businessmen in the rare earth smelting and applications businesses in Baotou in August 2013.

licenses among local market actors. A mining license is the prerequisite to control over the mineral resource and the upstream primary ore production. High market concentration of mining licenses proved to be helpful in negotiating mergers and acquisitions. Corporate mergers and acquisitions is a key part of Beijing's agenda to restructure the entire rare earth industry into champion companies (supersized state-owned modern conglomerate groups capable of both competing in the international market and dominating the domestic market) that would abide Beijing's policies. Thus higher market concentration of mining licenses would facilitate greater state capacity in implementing its reregulation policies.

The Baiyun-ebo mine in North China is owned by Baotou Steel, thus the company maintains a monopolistic type of control over the rights to the mineral resources in North China. At the same time of the release of the *Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earth Industry* in May 2011, the Inner Mongolia Autonomous Region provincial government released the *Consolidation and Abolishment Plan for Rare Earth Upstream Companies*. The plan called to have all the other smelting producers in the autonomous region, 35 in total, to be either shut down or merged into Baotou Steel. Yet these companies, some of which had sizable production capacity and private assets, would not simply close down or be merged without adequate compensation. As the negotiation process between Baotou Steel and all the other companies took longer than expected, to speed up the process, the Inner Mongolia government allowed Baotou Steel to withhold primary ore supply to the smelting companies. (Xu, 2011) By December 2012, among the 35 companies, 4 were abolished with no compensation, 1 changed its production to other industries, 18 were closed down with compensation, and the rest 12 signed contracts with Baotou Steel to give 51% of the total share of these companies. (Baotou Steel, 2012)

On the other hand, mining licenses in South China were far less concentrated among market actors, leading to a protracted battle in forming conglomerates. As explained in Chapter 6 and Chapter 7, in South China, after successive bureaucratic reforms in the late 1990s and early 2000s, rare earth mining licenses were spread out amongst a central SOE, a few local provincial-level and prefecture-level SOEs and several rural county-level companies. A lower concentration of mining licenses among market actors in South China resulted in more primary ore suppliers eligible to become the major conglomerate. Thus with more eligible players, there were more competition in mergers and acquisitions of mining and smelting companies and at the same time more resistence to corporate takeover without adequate compensation or political connections[366]. In particular, several local provincial-level and prefecture-level SOEs were looking to hold on to their mining licenses and corresponding mineral resources against potential takeover and also to acquire more mining licenses through acquiring smaller rural companies with mining licenses. Local companies also competed with each other and with central SOEs in acquiring more assets (new mining deposits yet to be

[366] Political connection could help facilitate the acquisition of mining licenses and mediate potential conflicts of interests. China Aluminimum, a central SOE, was able to break into rare earth mining with no prior licenses and consolidate the rare earth resource in Guangxi Province through getting the only mining license to explore and mine the rare earth deposit in Guangxi Province since 2011. The author learned from interviews with some industry insiders that the deal was successful in getting the support of the local government, partially because the political connection brought by Guo Shengkun, the Party Secretary of the Guangxi Provincial Government in 2007-2012. Previous to his top local post in the party leadership at Guangxi Province, Guo was the top leader in China Aluminum, serving as the founding CEO, the party secretary and the chairman of the board from 2001 to 2004.

explored, or smelting companies, or companies producing mid-stream products) to boost their chance of being recognized as prospective “super-sized enterprises”. By controlling the mineral resources and acquiring more assets, the local SOEs would gain higher chance of being selected as Beijing’s choice of conglomerate. The local provincial/prefecture governments that backed the affiliated local SOEs would have greater leverage in decision making in the industry after the restructuring is completed. The original plan of consolidating the market actors in South China into one conglomerate ended up becoming a protracted battle. By 2015 Beijing settled on a modified plan of compromise, selecting five enterprises (two central SOEs and three local SOEs) to lead the restructuring process in South China. Beijing’s original plan to consolidate industry production into a single conglomerate never stood a chance.

New international market changes would likely sustain the local companies’ advantages in control over the mining licenses in South China. The mineral deposit in Baiyun-ebo region is high in LREEs, meaning that the major products from North China are light rare earth products such as lanthanum oxide and cerium oxide. LREEs have historically been priced at much lower price than HREEs due to relatively higher global abundance in the earth’s crust. Such light rare earth products can be produced outside of China in abundance as well: in fact, the major non-China producers, such as Molycorp in the U.S. and Lynas in Australia/Malaysia that have restarted production in their respective mines after China tightened its regulations in 2008, are primarily LREE suppliers. On the other hand, HREEs have been solely produced from South China’s ionic clay deposits for the last two decades, with no viable production source outside of

China in the short term. Thus the local mining SOEs in South China would not have to worry about potential international competition offering alternatives of mineral supply.

9.4 Conclusion

This chapter identifies the three local-level independent variables influencing Beijing's capacity to effectively implement industrial policies to achieve the state's goals. In South China, lower geographical concentration of mineral deposits, lower technology intensity of production, and lower market concentration of mining licenses led to more failures in policy implementation in the rare earth industry, compared to North China. Unfortunately for Beijing, such factors contributing to the messy picture of policy enforcement in South China will stay. The geography of mineral deposits and the technical method of production required for mining the deposits are naturally determined and unlikely to be changed. The concentration of mining licenses among market actors is also unlikely to be changed, as it would be highly unlikely for the state to revoke or take back the licenses and corresponding mining rights held by local SOEs by force (though not entire impossible).

CHAPTER 10 CONCLUSION

Government policy is like the moon. It is different in the middle of the month than it is on the first day of the month. Government policy is also like the sun. When it shines on you, you flourish. - Chinese proverb

This thesis studies the role of the Chinese state in the development of the rare earth industry. China's rare earth industry has rapidly grown since the late 1970s and dominated global production since the late 1990s, producing non-renewable mineral resources vital to the manufacturing industries and national defense. Theoretical discussions about the role of the state in China's economic development abound. Competing theoretical camps exist: some argue for the state as the deregulator voluntarily retreating from the market; some argue for the state as the re-centralizer maintaining control over the market actors; some argue for the state as a fragmented authoritarian power consisting of different agenda-driving factions; some argue for the state as a predatory regime without political accountability. Using the case of the rare earth industry, one of the few industries that achieved rapid growth and claimed significant share of the global market, this thesis presents the role of the state as primarily engaging in "reregulation". Beijing has long recognized the value of rare earths as strategic minerals. In industry liberalization and market development since 1978, Beijing has set concrete goals to utilize and preserve the strategic value relevant to the state, and Beijing has consistently introduced new policies and regulations and adjusted existing policies and regulations. Yet Beijing's ability to steer industry development to fit its determined goals and policy targets has been constrained. This study analyzes the variables influencing the state capacity of enforcing its industrial policies in reregulation of the rare earth industry. The study finds that national-level independent variables (State Council's bureaucratic authority systems over market actors, the local cadre management system, the introduction and enforcement of specific property rights and criminal laws) and subnational level independent variables (the geographical concentration of local mineral deposits, the technological intensity of local mining production, the local market concentration of mining licenses) influence the state capacity in reregulation of the rare earth industry.

The importance of REEs as critical minerals were well recognized by senior Chinese government officials dating back to the early years of the People's Republic of China. In the planned economy era of the 1950s to the mid-1970s, the Chinese state was a dominating force in industry development. The state's primary focus was to develop the defense utility of the rare earth industry. Institutional support from Beijing allowed the industry to bypass fiscal and technical constraints typical in junior mining project development within a short period of time. Though successive political movements in the Maoist era, notably the Cultural Revolution, damaged China's economy and science and technology institutions, the rare earth industry suffered relatively less damage due to its affiliation with the military and utility for defense applications.

After China embarked on the marketization and opening up of its economy in 1978, the state's focus on the value of the rare earths shifted from their defense utility to their economic utility as the raw materials for export. Rare earth export would enable China to both gain foreign currencies and develop the backward regions, as well as to cement strategic ties with the western advanced economies as China sought to integrate itself into the global market. In this period from 1978 to 1997, the state's goal was achieving global dominance in production and trade while transitioning towards a more liberalized market from central planning. The state introduced more industry-specific policies, regulations, initiatives to promote as well as regulate the process of marketization and industry development. The measures included export promotion and tax rebate, production promotion and regulation through high-level state plans, restrictions on foreign investment in mining and smelting, production and export control on specific primary products, and support for basic research and high-tech development zones. At the same time, political and legal institutional changes, not specific to the rare earth industry, influenced the state capacity of steering in this industry to its determined policy objectives. These institutional variables include the bureaucratic system over market actors, the local cadre management system and the property rights legal institutions. By 1997 China's rare earth industry had rapidly grown to near global dominance in rare earth production and export, having successfully convinced major western consumer companies to source materials from China for the long term.

As China became the global default supplier of REEs after 1998, the state goals in the rare earth industry changed from maximizing the export to the focus on sustainable development and domestic industry upgrading to preserve the value of China's supply of such critical minerals. The state-imposed reregulation measures in this period between 1998 and 2007 included mining license control and mining quota, restrictions on foreign investment, export quota and tariff on low-end products, funding and project approval priority for industry upgrading, attempted consolidation of industry into two national SOEs, and environmental treatment and inspections. National-level institutional changes did not all yield impact to policy implementation in the state's favor. Successive bureaucratic reforms resulted in weakened central bureaucratic authority over the market actors. Inefficient legal prosecution procedures contributed to the lack of local enforcement of central government policies. Well-intended changes to the local cadre management system did not fundamentally change its mantra of economic-growth-based promotion and its inherent incompetence in monitoring and evaluating cadre behavior. The result of Beijing's policies was a mix of success and failure. China sustained its leading position in global rare earth supply, and with industry upgrading and global migration of manufacturing to China its domestic consumption of rare earths climbed up to rival the export. Rare earth production and export both showed significant industry upgrading from primarily low-end unprocessed products to many categories of products of higher value, though the production and export of high-tech products was still small compared to the total volume. On the other hand, Beijing was not able to strictly enforce mining control and clamp down on illegal mining and smuggling, to restructure the market into large conglomerates, or to curb the environmental destruction from industrial production.

The current reregulation since 2008 has seen much more forceful policy campaign to reassert control over the rare earth industry from Beijing. At the macroeconomic level the Chinese state faced the dire task of lifting the economy from the impact of the 2008 global financial crisis and implemented massive stimulus programs to boost domestic demand and the development of strategic and emerging industries. In the rare earth industry, Beijing's reregulation goals grew to be more multi-facted to utilize and preserve the strategic value of the rare earth resources in this new macroeconomic environment.

The state's goals include sustainable production and environmental protection, technology upgrading to fulfill domestic demand, securing resource advantage to facilitate downstream development of strategic and emerging industries, and breaking the barrier to international markets imposed on domestic producers of higher-value applications. The central government has introduced and adjusted rules and policies on production quota, taxation and licensing, market entry, export quota, tariff and export licensing, funding for tech upgrading, environmental treatment and inspections. Beijing has led annual crackdown campaigns against illegal mining and smuggling and a new restructuring campaign seeking to consolidate the industry into a few mega-sized state-owned conglomerates. The current period of reregulation has seen changes to the political and legal institutions that influence state capacity. The increased coordination within the State Council, the strengthened local cadre evaluation and recalibrated cadre promotion incentives, and the increased cross-regional collaboration in law enforcement have contributed to better enforcement of Beijing's policies. However, existing lack of administrative independence of specific local bureaus and inspectors, as well as lack of effective criminal prosecution have continued to allow for and encourage the evasion of Beijing's mandates.

The current round of reregulation has resulted in a mix of success and failures. Beijing's campaigns have resulted in notable progress in technology upgrading and environmental protection. Yet efforts to control production volume and to eradicate illegal activities has been not so successful. The original plan to consolidate the industry into 2-3 conglomerates in two years suffered significant time lag and local pushback and was recently revised to include two central SOEs and four local SOEs. The drastic policy changes prompted market price swings, negatively impacting downstream industries both at home and abroad. In some cases, Beijing's industrial policies created excessive regulatory requirements and unequal treatment for domestic companies. In other words, the campaign-style policies led by the party from the center still have a long way to go to ensure effective enforcement and win full cooperation from the local market actors.

A natural policy question is what Beijing can do better to enhance its state capacity to steer industry development to fit its reregulation goals and policies. This thesis shows that at the national level, more fundamental political institutional changes, not specific to the rare earth industry, are needed to bring about long-lasting changes more than what the current annual crackdowns will do. The local cadre management system would need to be improved to strengthen the monitoring and evaluation of local government performance based on well-rounded metrics that include not only economic growth but also other records such as environmental performance. Local discipline inspections and auditing officers, who the state relies on to monitor local government performance, would need to have greater independence in their work to be shielded from unnecessary influence of the local administrations. The legal institutions persecuting illegal operations and thus protecting the interests of law-abiding companies needs to be strengthened to ensure long-term voluntary compliance with state rules. Instead of a campaign-style crackdown almost every year, effective legal prosecution can replace central dispatchers to serve as a useful, long-term deterrent against illegal business activities and local cadre corruption. At the subnational level, compared to North China (with Baiyun-ebo as its major mining region), South China (with Gannan-Yuebei as its major mining region) has lower geographical concentration of mineral deposits, lower technology intensity of production, and lower market concentration of mining licenses. These factors, shaped either by nature or by long-time institutional changes, unfortunately would stay. Beijing would need to accept its agendas have not been a smooth ride in the southern provinces and would not run smoothly.

As the world's largest rare earth producer (and likely remaining the largest for years to come), China's reregulation has led to strong international concern of Chinese state intervention as a potential risk in global supply chain and international politics. This thesis shows that on the one hand, because of the strong linkage between China and the advanced western economies in global rare earth supply chain, China's domestic industrial policies can have spillover effects on the global market. China's reregulation campaign and significantly price swings in the domestic market has affected the global market price and led to overseas companies taking various measures (such as joint venture with Chinese smelting companies) to mitigate sourcing risk. Beijing has scraped export quota and tariff in 2015 to comply with the WTO ruling, giving more equal footing ground to domestic and foreign consumers. Beijing would also likely be very cautious in its future policies to avoid causing a price swing similar to the 2011-2013 period in the future, as the price swing has shown to cause significant damage to domestic downstream producers and ran contrary to the state's interest to develop downstream industries. On the other hand, the thesis shows that the potential threat of China using its rare earth supply as an effective weapon in international politics is likely overblown. The alleged rare earth export halt to Japan after the Senkaku/Diaoyu Island incident in the second half of 2010 was widely reported as a sign of China using REEs as a diplomatic weapon. Yet the analysis shows that the alleged embargo cannot be substantiated based on the official Japanese import data available. In addition, the thesis shows that while Beijing’s reregulation has facilitated the industry’s strong growth and its dominance in global production so far, Beijing has been limited in its capacity to impose rules and policies to fully achieve the goals and policy targets that it envisioned. Institutional factors at the national level, as well as geographical, technical and market factors at the subnational level, would continue to pose obstacles to Beijing’s progress maintaining and reasserting its full and willful control over this strategic industry.

REFERENCES

Abraham, D. (2012). *The Battle for New Resources: Minor minerals in green technologies*. Research Institute of Economy, Trade and Industry (RIETI). Retrieved from http://www.rieti.go.jp/jp/publications/pdp/12p005.pdf

Acemoglu, D., Ticchi, D., & Vindigni, A. (2006). Emergence and persistence of inefficient states. National Bureau of Economic Research Working Paper Series, No. 12748.

Acemoglu, D., Robinson, J. A., & Woren, D. (2012). *Why nations fail: the origins of power, prosperity and poverty (Vol. 4)*. New York: Crown Business.

Agence France-Presse (AFP). (2012, February 26). *Thousands protest Malaysia rare earth plant.* Retrieved from http://www.canada.com/business/Thousands+protest+Malaysia+rare+earths+plant/6211005/story.html

Akademi Sains Malaysia (the Academy of Sciences Malaysia). (2011). *Rare Earth Industries: Moving Malaysia's Green Economy Forward.* Retrieved from http://akademisains.gov.my/download/rareearth/RE_Report_English.pdf

Alonso, E., Sherman, A. M., Wallington, T. J., Everson, M. P., Field, F. R., Roth, R., & Kirchain, R. E. (2012). Evaluating Rare Earth Element Availability: A Case with Revolutionary Demand from Clean Technologies. *Environmental Science & Technology 46*, 6: 3406–3414.

Alpermann, B. (2010). *China's Cotton Industry: Economic Transformation and State Capacity.* New York: Routledge.

American Physical Society (APS) & Materials Research Society (MRS). (2011, February 18). *Energy Critical Elements: Powering Our High-Tech World* [PDF]. Washington, DC: APS. Retrieved from *http://www.aps.org/policy/reports/popa-reports/upload/elementsfactsheet.pdf.*

Anderson, P. (1974). *Lineages of the Absolutist State*. New York, NY: New Left Books.

Aoyama, I. (2003, October 22). 2002 年の日本のレアアース需給状況等について [About Japan's Rare Earth Supply and Demand in 2002]. In Information Center of the Japan Metals and Mining Corporation (Ed.), *Proceedings of the 15th Sino-Japan Rare Earth Communications Meeting* (pp.17-25). Tokyo.

Areddy, J.T. (2012, March 11). Deal Shows China's Sway in Rare-Earth Minerals. *Wall Street Journal*. Retrieved from http://www.wsj.com/articles/SB10001424052702303717304577274882847317306

Atkinson, M. M. & Coleman, W. D. (1989). Strong States and Weak States: Sectoral Policy Networks in Advanced Capitalist Economies. *British Journal of Political Science*, 1, 47-67.

Bai, L., Li, X., Feng, D., & Guo, S. (1999). Cujin Baotou Shi Xitu Chanye Fazhan de Huanjin Baohu Fang'an [Environmental Protection Plan for Improving the Development of the Rare Earth Industry in the City of Baotou]. *Baotou Huanbao [Baotou Environmental Protection], 15* (1), 32-35.

Bai, Y. & Xu, S. (2012). Zhongguo Zhengfu Caigou Cujin Zizhu Chuangxin de Jiaose Fenxi [Analysis of the Role of the Chinese Government in Procurement of Indigenous Innovation Products]. *Shoudu Jingji Maoyi Daxue Xuebao [Journal of Central Economics and Trade University]*, 2, 18-23.

Barboza, D. (2008, November 9). China Unvails Sweeping Plan for Economy. *New York Times*, p.A1.

Baotou Rare-Earth Hi-Tech Industrial Development Zone. (n.d.) *Rare Earth: an Introduction.* Retrieved from http://www.rev.cn/en/int.htm.

Baotou Research Institute of Rare Earths (BRIRE). (1983, April 30). *Baogang Xitu Gongsi Yingyao Canjia Meiguo Juban De Zhanlanhui [Baotou Iron & Steel and Rare Earth Company Invited to Attend Exhibition in the U.S.]*. Retrieved from http://www.cre.net/show.php?contentid=17230

Baotou Steel Rare Earth Company. (2012). Neimenggu Baogang Xitu (Jituan) Gaokeji Gufen Youxian Gufen yu Neimenggu Zizhiqu Xitu Shangyou Qiye Qianshu <<Zhenghe Chongzu Kuangjia Xieyi>> de Gonggao [Announcement of the Issurance of Restructuring Framework Contract Signed by Inner Mongolia Baotou Steel Rare Earth (Corp.) High-tech Ltd. Company and Upstream Companies in Inner Mongolia Autonomous Region]. Retrieved from http://www.cninfo.com.cn/finalpage/2012-12-28/61960781.PDF?COLLCC=135411453&

Baum, R. & Shevchenko A. (1999). The “State” of the State. In Merle Goldman and Roderick Macfarquhar (Eds.) *The Paradox of China’s Post-Mao Reforms* (pp. 333 – 60). Cambridge, MA: Harvard University Press.

Bernstein, T. P., & Lü, X. (2003). *Taxation without representation in contemporary rural China*. Cambridge: Cambridge University Press.

Biedermann, R. (2014). China’s rare earth sector – between domestic consolidation and global hegemony. *International Journal of Emerging Markets, 9*(2), 276–293.

Binnemans, K., Jones, P. T., Blanpain, B., Gerven, T. V., Yang, Y., Walton, A., & Buchert, M. (2013). Recycling of rare earths: a critical review. *Journal of Cleaner Production, 51*(0), 1 – 22. doi:10.1016/j.jclepro.2012.12.037

Blecher, M. J. (1996). *Tethered deer: government and economy in a Chinese county*. Stanford, CA: Stanford University Press.

Blecher, M. & Shue, V. (2001). Into Leather: State-led Development and the Private Sector in Xinji. *China Quarterly, 166,* 368-393.

Bloomberg New Energy Finance. (2015, January 22). U.S. wind new build makes substantial rebound in 2014. Retrieved from http://about.bnef.com/content/uploads/sites/4/2015/01/BNEF_PR_20150122_Wind-installations-in-2014.pdf

Bradsher, K. (2009, December 26). Earth-friendly elements, mined destructively. *New York Times,* p. A1.

Bradsher, K. (2010a, September 23). Amid Tension, China Blocks Crucial Exports to Japan. *New York Times,* p.B1.

Bradsher, K. (2010b, November, 11). China Still Bans Rare Earths for Japan, Executives Say. *New York Times,* p. B1.

Bradsher, K. (2011a, March 9). Taking a Risk for Rare Earths. *New York Times,* p. B1.

Bradsher, K. (2011b, August 24). Chasing Rare Earths, Foreign Companies Expand in China. *New York Times,* p.B1.

Breslin, S. G. (1996). China: developmental state or dysfunctional development? *Third World Quarterly*, *17*(4), 689-706.

British Geological Survey. (2011). *Rare Earth Elements Profile [PDF]*. Retrieved from www.bgs.ac.uk/downloads/start.cfm?id=1638

Brock, D. (2009). Science Innovation during the Cultural Revolution: Notes from the *Peking Review. Southeast Review of Asian Studies, 31,* 226-232.

Cai, Y., Min, W., Wang, L. (2002). Damao Xitu Youxian Gongsi Xitu Shengchan Fangshexing Huanjing Yingxiang Xianzhuang Diaocha [Investigation of the Current Environmental Impact of Radioactivity in Production by Damao Rare Earth Limited Company]. *Baotou Huanbao [Baotou Environmental Protection], 18* (1-2), 25-29.

Cai, H., & Treisman, D. (2006). Did Government Decentralization Cause China's Economic Miracle? *World Politics, 58(4),* 505-535.

Cao, C. (2013). Science Imperiled: Intellectuals and the Cultural Revolution. In C. N. Wei & D. E. Brock (Eds.), *Mr. Science and Chairman Mao's Cultural Revolution: Science and Technology in Modern China* (pp. 119-142). Lanham, MD: Lexington Books.

Castilloux, R. 2013. *Sifting the Winners from Losers Amidst the Impending Rare-Earth Industry Shakeout.* Sudbury, Canada: Adamas Intelligence.

Chang, L. & Hui, Y. (2015, August 11). Rare earth firms slip further into the red. *China Daily,* p. 16.

Chaudhry, K.A. (1993). The Myths of the Market and the Common History of Late Developers. *Politics & Society, 21*(3), 245-274.

Chen, D. (1994). Gaige Mianlin de Xin Maolun yu Jiakuai Shichanghua de Duice Xuanze [New Conflicts Facing the Reform and Choices for Speeding up Marketization]. *Jingji Gaige yu Fazhan [Economic Reform and Development],* 5, 16-18.

Chen, S. (2003, September 30). Xitu Pei'e Fenke de Sikao [Thoughts on the Distribution of Rare Earth Quota]. *Xitu Shichang [Rare Earth Market]*, p.4.

Chen, W. (2012, March 15). Rare earth case reveals U.S. hypocrisy. *China Daily*. Retrieved from http://www.china.org.cn/opinion/2012-03/15/content_24904198.htm

Chen, Z. (2010). *China Rare Earth Industry: Resources, Domestic Market and Environment.* Retrieved from http://chinarareearths.net/pdf-china-rare-earth-industry-resources-domestic-market-and-environment.html

China Development Research Foundation. (2011). Zhongguo Xitu Kaifa Yu Chukou Zhengce Ji Zhanlue Zai Sikao (Analysis of China's Rare Earth Development and Export Policy and Strategy). *China Development Research Foundation Internal Report.* Retrieved from http://www.cdrf.org.cn/uploads/soft/PDF/20120329/baogao109.pdf

China Internet Information Center. (2009a). 1988: Private Sector of the Economy. Retrieved from http://www.china.org.cn/features/60years/2009-09/16/content_18535172.htm

China Internet Information Center. (2009b). 1981: Dual Track Price System. Retrieved from http://www.china.org.cn/features/60years/2009-09/16/content_18534471.htm

China Internet Information Center. (2009c). 1983: Household Responsibility System. Retrieved from http://www.china.org.cn/features/60years/2009-09/16/content_18534697.htm

China Internet Information Center. (2009d). 1980: Special Economic Zone (SEZ). Retrieved from http://www.china.org.cn/features/60years/2009-09/16/content_18533947.htm

China Internet Information Center. (2009e). 1990: The establishment of stock exchanges. Retrieved from http://www.china.org.cn/features/60years/2009-09/16/content_18535248.htm

China Internet Information Center. (2009f). 1996: The reform of the foreign exchange management system. Retrieved from http://www.china.org.cn/features/60years/2009-09/16/content_18535687.htm

China Non-ferrous Metals Import & Export Company. (1992). Zhongguo Youse Jinshu

Jingchukou Zonggongsi [China Non-ferrous Metals Import & Export Company]. *Zhongguo Youse Jinshu Xuebao [China Nonferrous Metals]*, 1, 97.

China Rare Earth Information. (2006). Chinese RE performance materials on the fast developing way. *China Rare Earth Information Center, 12*(5), 4.

China Rare Earth Net. (2008). Xitu Deng Hangye Guanliquan Yizhi Gongye he Xinxihua Bu Yuancailiao Gongye Si [Supervision Over Rare Earth Industry Transferred to the Department of Raw Materials Industries of the Ministry of Industry and Information Technology]. Retrieved from http://www.cre.net/show.php?contentid=735

China Rare Earth Society (CSRE). (2013). Jiji Yingdui Zhudong Chuji [Act Proactively]. *Zhongguo Youse Jingshu [China Non-ferrous Metals]*, 1, 54-55.

Chinese Academy of Sciences (CAS). (2005). Xu Guangxian Shi Changxu Deng 14 Wei Yuanshi Jinji Huyu Baohu Baiyun-ebo Kuang Tu he Xitu Ziyuan Bimian Huanghe he Baotou Shou Fangshexin Wuran [14 Academicians of the Chinese Academy of Sciences including Xu Guangxian and Shi Changxu Urgently Calls for the Protection of Thorium and Rare Earth Resources in Baiyun-ebo Mine and the Prevention of Radioactive Pollution to the Yellow River and Baotou]. Retrieved from http://www.cas.cn/ys/ysjy/200510/t20051020_1688997.shtml

Chinese Academy of Sciences (CAS). (2009a). *Science & Technology in China: A Roadmap to 2020*. Beijing: Science Press & Springer.

Chinese Academy of Sciences (CAS). (2009b, August 24). He Zuoling Yuanshi [Fellow Bio: He Zuoling]. Retrieved from http://www.igg.cas.cn/rcjy/yszj/200908/t20090824_2436236.html

Central Committee of the Communist Party of China. (1985). *Zhonggong Zhangyang Guanyu Kexue Jishu Tizhi Gaige de Jueding [The Decision of the Central Committee of the Communist Party of China on Science and Technology Institution Reform]*. Retrieved from http://www.most.gov.cn/kjzc/gjkjzc/gjkjzczh/201308/P020130823574949214123.pdf

Central Committee of the Communist Party of China. (1995). *Zhonggong Zhangyang Guanyu Zhiding Guomin Jingji He Shehui Fazhan "Jiu Wu" Jihua He 2010 Nian Yuanjing Mubiao De Jianyi [The Recommendation of the Central Committee of the Communist Party of China on Drafting the Ninth "Five-Year Plan" of National Economic and Social Development and 2010 Long-Term Vision]*. Retrieved from http://ghs.ndrc.gov.cn/ghwb/gjwngh/200709/P020070912631947710061.pdf

Central Committee of the Communist Party of China. (1999). *Zhonggong Zhangyang Guanyu Guoyou Qiye Gaige he Fazhan Ruogan Zhongda Wenti de Jueding [The Decision of the Central Committee of the Communist Party of China on Several Important Issues in the Reform of the State-owned Enterprises]*. Retrieved from http://cpc.people.com.cn/GB/64162/71380/71382/71386/4837883.html

Central Committee of the Communist Party of China. (2005). *Zhonggong Zhongyang Guanyu Zhiding "Shiyiwu" Guihua de Jianyi [Suggestions of the Central Committee of the Communist Party of China on Drafting the 11th Five-Year Plan]*. Retrieved from http://cpc.people.com.cn/GB/64162/64168/64569/65414/4429220.html

China Rare Earth Net. (2006). 2006 Nian Xitu Chukou Xinshi Qianxi [Simple Analysis of the Rare Earth Export Situation in 2006]. *Xitu Xinxi [Rare Earth Information],* 5, 8.

Collier, D. (2011). Understanding Process Tracing. *PS: Political Science and Politics, 44*(4), 823-30.

Constantinides, S. (2009). *The demand for rare earth elements in permanent magnets*. Rochester, NY: Arnold Magnetic Technologies.

Cui, Z. (2003). China's Export Tax Rebate Policy. *China: an International Journal*, 1, 339-349.

Cui, Y. (2011, October 27). Hong Feng: Xitu Meiyou Maicheng Baicaijia [Interview with Hong Feng: Rare Earths were Not Sold at "Dirt Cheap" Price]. *Shidai Zhoubao [Time Weekly]*. Retrieved from http://www.time-weekly.com/story/2011-10-27/119933.html

Dai, Z. (2005a, April 4). Nanbei Jituan Chongzu Geqian Zhongguo Xitu Chanye Qiantu Weibu [South and North China Corporation Restructuring Abandoned: Unclear Future for Chinese Rare Earth Industry]. *Zhongguo Gongye Bao [China Industry News]*, p.2.

Dai, Z. (2005b, June 7). Wuyan de Jieju: Nanbei Xitu Jituan Geqian Liuxia de Sikao [Speechless Ending: Thoughts on Abandoned South and North China Rare Earth Corporation]. *Zhongguo Youse Jinshu Bao [China Nonferrous Metals Daily]*, p. 3.

Deng, X. (1978, March 18). *Zai Quangguo Kexue Dahui Kaimushi Shang De Jianghua [Speech at the Opening Ceremony of the National Science Congress]*. Retrieved from http://scitech.people.com.cn/GB/25509/56813/57267/57268/4001431.html

Deng, R. (2000). *Wo de Fuqing Deng Xiaoping: Wenge Suiyue [My Father Deng Xiaoping: Cultural Revolution Years]*. Beijing: Zhongyang Wenxian Chubanshe [Central Party Literature Press].

Department of Organization of the Central Committee of the Communist Party of China. (1980). *Guanyu Chongxin Banfa <<Zhonggong Zhongyang Guanli de Ganbu Zhiwu Mingcheng Biao>> de Tongzhi [Circular on the Reissuance of the List of Cadres on the Nomenclature of the Central Committee of the Communist Party of China]*. Beijing.

Department of Organization of the Central Committee of the Communist Party of China. (1983). *Guanyu Gaige Ganwu Guanli Tizhi Ruogan Wenti de Guiding [Regulation about Several Issues in Reforming Cadre Management System]*. Beijing.

Department of Organization of the Central Committee of the Communist Party of China. (1988). *Difang Zhengfu Gongzuo Bumen Lingdao Ganbu Niandu Kaohe Fang'an [Evaluation Scheme of Local Government Bureau Cadre Annual Review]*. Beijing.

Department of Organization of the Central Committee of the Communist Party of China. (1991). *Guanyu Ganbu Shuangchong Guanli Gongzuo Ruogan Wenti de Tongzhi [Circular on Several Issues Concerning Dual Management of Cadres]*. Beijing. Retrieved from http://cpc.people.com.cn/GB/64162/71380/71387/71591/4855065.html

Dong, Z. (1998). Goujian Tongyi Gaoxiao de Difang Jijian Jiancha Gongzuo Wangluo [Building a Unified Efficient System of Discipline Inspection and Supervision]. *Neibu Wengao [Internal Documents], 24*, 16-17.

Dou, X. (2012). Yiding Yao Ba Xitu De Shi Banhao- Jinian Deng Xiaoping Tongzhi Zhongyao Xitu Zhishi Fabiao 20 Zhounian ["We Must Ensure Success on Rare Earths" – Commemorating the 20th Anniversary of Comrade Deng Xiaoping's Important Directive on Rare Earths]. *Xitu Xinxi [Rare Earth Information]*, 6, 32-33.

Du, J. (2013, August 13). Rare earth alliance to fight Japan's patent barrier. *China Daily*. Retrieved from http://usa.chinadaily.com.cn/business/2013-08/13/content_16889366.htm

Du, S. (1993). Baiyun-ebo Da Tie Kuang de Faxianzhe Ding Daoheng [Discoverer of the Baiyun-ebo Iron Deposit Ding Daoheng]. *Guizhou Wenshi Congkan [Guizhou Literature and History]*, 2, 71-73.

Du, W. (2002). Dui Gannan Lizixing Xitu Kaifa Huanjing Baohu Wenti de Jidian Sikao [Some Ideas in View of the Problems of Environmental Protection in Development in Ion-type Rare Earths in Gannan Area]. *Jiangxi Youse Jingshu [Jiangxi Nonferrous Metals], 16* (4), 3-5.

Du, J. (2013, August 13). Rare earth alliance to fight Japan's patent barrier. *China Daily*. Retrieved from http://usa.chinadaily.com.cn/business/2013-08/13/content_16889366.htm

Du, X. & Graedel, T.E. (2011). Global In-Use Stocks of the Rare Earth Elements: A First Estimate. *Environmental Science & Technology, 45,* 4096-4101.

Duckett, J. (2006). *Entrepreneurial State in China: Real Estate and Commerce Departments in Reform Era Tianjin*. London: Routledge.

Eckstein, H. (1975). Case Study and Theory in Political Science. In Fred I. Greenstein and Nelson W. Polsby, eds., *Handbook of Political Science*, vol.7, Reading, MA: Addison-Wesley.

Economic Information & Agency. (2009, June 15). Li Rongrong: Guli Yangqi yu Mingqi Zhanlue Chongzu [Li Rongrong: Encourage Central SOEs to strategically consolidate assets with Private Companies]. Retrieved from http://www.jdonline.com.hk/content_new/detail.php?news_id=39656

Economic Information & Agency. (2010, February 12). Youse Jingshuye Jianbing Chongzu Zhidao Yijian Shangbao Guowuyuan [Recommendation on Mergers and Acquisitions in Non-ferrous Metals Industries Submitted to the State Council]. Retrieved from http://www.jdonline.com.hk/content_new/detail.php?news_id=42962

Economy, E. C. (2007). The Great Leap Backward? *Foreign Affairs, 86*(5): 38-60.

European Commission. (2014, May). *Report on Critical Raw Materials for the E.U.: Report of the Ad hoc Working Group on defining critical raw materials.* Brussels: European Commission.

Evans, P.B., Rueschemeyer, D. & Skocpol, T. (1985). On the road toward a more adequate understanding of the state. In: P.B. Evans, D.Rueschemeyer & T. Skocpol (Eds.), *Bringing the State Back In* (pp. 347–366). Cambridge: Cambridge University Press.

Evans, P. B. (1989). Predatory, developmental, and other apparatuses: a comparative political economy perspective on the third world state. *Sociological Forum*, *4* (4), 561-587.

Evans, P. B. (1995). *Embedded Autonomy*. Princeton, NJ: Princeton University Press.

Evans, P. & Rauch, J. E. (1999). Bureaucracy and growth: A cross-national analysis of the effects of "Weberian" state structures on economic growth. *American Sociological Review*, *64*(5), 748-765.

Falconnet, P. (1992). Rare Earth Industry Update. *Materials Chemistry and Physics, 31*, 79-83.

Fan, S. & Qing, M. (2013, December 9). Baogang Xitu Mingnian Buzai Xiang Weihuangku Paifang Feishui [Baotou Steel Rare Earths Would Stop Dumping Waste Water into Tailings Dam Next Year]. *Baotou Ribao [Baotou Daily]*, p.1.

Fang, H. (2010a, December 25). Xitu Xiehui Chengli Zaiji: Jiulong Zhishui Reng Nanbian [Rare Earth Industry Association Soon to Establish: Multiple Agencies' Divided Control Unlikely to Change]. *Zhongguo Jingying Bao [China Business Journal]*, Retrieved from http://www.cb.com.cn/

Fang, H. (2010b, September 22). Xitu Chukou Pei'e Buneng "Qingzhong Bufen" [Rare Earth Export Quota Should not Lump Together Heavy and Light Rare Earths]. *Zhongguo Guotu Ziyuan Bao [China Land and Resources News]*, p.6.

Fang, H. (2012, December 1). Zhong Ri Haiwai Nengyuan Anzhan [Sino-Japan Rivalry over Overseas Energy]. *Zhongguo Jingying Bao[China Business Journal]*. Retrieved from http://futures.hexun.com/2012-12-01/148582344.html

Feigenbaum, E.A. (2003). *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age.* Palo Alto, CA: Stanford University Press.

Fei, Z. (1990). *Zhengzai Jueqi de Zhongguo Youse Jingshu Gongye Zonggongsi [China Non-ferrous Metallurgical Industry Company on the Rise]*. Beijing: Renmin Chubanshe [People's Press].

Fewsmith, J. (1994). *Dilemmas of reform in China: Political conflict and economic debate*. Armork, NY: ME Sharpe.

Fligstein, N. (1996). Markets as Politics: A Political-cultural Approach to Market Institutions. *American Sociological Review, 61*(4), 656-673.

Ford Motor Company. (2014). *Sustainability Report 2013-2014.* Retrieved from http://corporate.ford.com/content/dam/corporate/en/company/sustainability-report-2013.pdf

Forster, C. (2006). *China's Secret Weapon? Science Policy and Global Power*. London: the Foreign Policy Centre.

Fujian Province Local Chronicle Database. (2002). *Fujiansheng Zhi: Qiyexing Jigou [Chronicle of Fujian Province: Corporations]*. Retrieved from http://www.fjsq.gov.cn/ShowText.asp?ToBook=202&index=59&

Fujian Province Local Chronical Editorial Commission Office. (2002). *Fujian Province Chronicles-Metallurgical Industry Chronicle [Fujiansheng Zhi Yejin Gongyezhi]*. Retrieved from http://www.fjsq.gov.cn/ShowText.asp?ToBook=147&index=146&

Gallagher, M. E. (2005). *Contagius Capitalism: Globalization and the Politics of Labor in China.* Princeton, NJ: Princeton University Press.

Gang, C. (2009). *Politics of China's environmental protection: Problems and Progress.* Hackensack, N.J.: World Scientific.

Geddes, B. (1996). *Politician's dilemma: building state capacity in Latin America*. Berkeley, CA: University of California Press.

George, A.L. & Bennett, A. (2005). *Case Studies and Theory Development in the Social Sciences.* Cambridge, MA: MIT Press.

Gerschenkron, A. (1962). *Economic Backwardness in Historical Perspective: A Book of Essays.* Cambridge, MA: Belknap Press of Harvard University Press.

Global Wind Energy Council (GWEC). 2014. *Global Wind Statistics 2013*. Brussels, Belgium: GWEC.

Gong, T. (2009). The Institutionalization of Party Discipline Inspection in China: Dynamics and Dilemmas. In Gong, T. & Ma, S. K. (Eds.) *Preventing Corruption in Asia.* London and New York: Routledge.

Gourevitch, P. (1978). The second image reversed: the international sources of domestic politics. *International Organization, 32*(04), 881-912.

Graedel, T. E., Harper, E. M., Nassar, N. T., & Reck, B. K. (2013). On the materials basis of modern society. *Proceedings of the National Academy of Sciences*. http://doi.org/10.1073/pnas.1312752110

Grande, E. (2001). The erosion of state capacity and the European innovation policy dilemma: A comparison of German and EU information technology policies. *Research Policy*, *30*(6), 905–921.

Gschneidner, K.A. (2011). Replacing the Rare Earth Intellectual Capital. *Magnetics Magazine, 10*(1), 6-8.

Guan, P. (2011, September 27). Zhongguo Yi You Jin 20 Nian Wei Shenru Kantan Xitu Chuliang [China Has Not Conducted Detailed Geological Survey of Rare Earth Deposits for about 20 Years]. *Dongfang Zaobao [Dongfang Daily]*. Retrieved from http://money.163.com/11/0927/04/7EUBS8KJ00253B0H.html

Guangdong Province Local Chronical Editorial Commission Office. (1996). Jinchukou Maoyi [Import and Export Trade]. In Guangdong Province Local Chronical Editorial Commission Office, *Guangdong Sheng Zhi – Yejin Gongye Zhi [Guangdong Province Chronicles – Metallurgical Industry Chronicle]*. Retrieved from http://www.gd-info.gov.cn/books/dtree/showSJBookContent.jsp?bookId=10753&partId=835&artId=48803

Guangxi Zhuang Autonomous Region Local Chronicle Editorial Commission Office. (1996). Zhongguo Yejin Jinchukou Guangxi Gongsi [Guangxi Subsidiary of the China Metallurgical Import & Export Company]. In Guangxi Zhuang Autonomous

Region Local Chronicle Editorial Commission Office, *Guangxi Tong Zhi – Waijingmao Zhi [Guangxi Zhuang Autonomous Region Chronicles-Foreign Trade Chronicle]*. Retrieved from http://www.gxdqw.com/bin/mse.exe?seachword=&K=a&A=43&rec=231&run=13

Guo, Y. (2007). *Jingji Zhuangui Zhidu yu Fubai [Economic Transition, Institution and Corruption]*. Beijing: Shehui Kexue Wenxian Chubanshe [Social Science Press].

Hagstrom, L. (2012). 'Power Shift' in East Asia? A Critical Reappraisal of Narratives on the Diaoyu/Senkaku Islands Incident in 2010. *The Chinese Journal of International Politics, 5* (3), 267–297.

Hall, P.A. (1986). *Governing the Economy*. Oxford, UK: Polity Press.

Hall, P. A. & Soskice D. (2001). *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage.* Oxford, UK: Oxford University Press.

Hall, P.A. & Taylor R.C.R. (1996). Political science and the three new institutionalisms. *Political Studies,* 44, 936–957.

Hanson, J.K. & Sigman, R. (2013). Leviathan's Latest Dimensions: Measuring State Capacity for Comparative Political Research. Paper presented at the World Bank Political Economy Brownbag Lunch Series. Retrieved from http://faculty.maxwell.syr.edu/johanson/papers/hanson_sigman13.pdf

Hao, Y., & Liu, W. (2011). Rare earth minerals and commodity resource nationalism. In: M.E. Herberg (Ed.), *Asia's Rising Energy and Resource Nationalism: Implications for the United States, China, and the Asia-Pacific* Region (pp.39-52). Washington, DC: National Bureau of Asian Research.

Hao, J. (2013, May 17). Xu Guangxian: Jiebukai de Xitu Qingjie [Xu Guangxian: Unwavoring Dedication to the Rare Earths]. *Zhongguo Kexue Bao [China Science News]*. Retrieved from http://news.sciencenet.cn/htmlnews/2013/5/277977.shtm.

Harvey, G. (2014, June 27). Arrests at Malaysian Rare Earths Refinery Protests. *The Diplomat.* Retrieved from http://thediplomat.com/2014/06/arrests-at-malaysian-rare-earths-refinery-protests/

Hatch, G. (2012, April 9). *Is there a gold standard for estimating rare-earth mineral* *resources and reserves?* Chicago, IL: Technology Metals Research. Retrieved from http://www.techmetalsresearch.com/2012/04/is-there-a-gold-standard-for-estimating-rare-earth-mineral-resources-and-reserves/

Hayes-Labruto, L., Schillebeeckx, S. J. D., Workman, M., & Shah, N. (2013). Contrasting perspectives on China's rare earths policies: Reframing the debate through a stakeholder lens. *Energy Policy, 63*(0), 55–68.

He, J. & Wang, H. (2007). Woguo Nvtiepeng Chanye Zhuanli Zhanlue Huanjing de Jidian Fenxi ji Xiangguan Jianyi [Analysis and Related Recommendations on the Strategic Environment of Patents in China's NdFeB Industry]. *Xitu [Chinese Rare Earths], 28* (5), 118-125.

He, S. (1997). NdFeB Lie Ru "863" Jihua [NdFeB Selected into the 863 Program]. *Cixing Cailiao ji Qijian [Magnetic Material and Applications], 28* (4), 55.

He, G. (2013). Gongwuyuan Guanli Gongzuo zhi Zhiwu Renmian yu Zhiwu Shengjiang [Appointment, Removal, Promotion and Demotion in Cadre Management]. Guangzhou Municipal Human Resources and Social Security Bureau. Retrieved from http://www.hrssgz.gov.cn/gzpi07/ywztc/gwygl/czsm/201312/P020131219407285932710.ppt

He, Y. (2014). Reregulation of China's rare earth production and export. *International Journal of Emerging Markets*, *9*(2), 236-256.

Heckscher, E. (1934). *Mercantilism*. London: Allen and Unwin.

Hedrick, J.B. (1999). *USGS 1999 Minerals Yearbook: Rare Earths*. Washington, D.C.: United States Geological Survey.

Hedrick, J.B. (2010, December 15). *Global Rare Earth Production: History and Outlook.* Presentation at the Center for Strategic and International Studies, Washington, D.C. Retrieved from http://www.*csis.org/files/attachments/101215_EnergyHedrick.pdf*

Herbst, J. (2010). *States and Power in Africa.* Princeton, NJ: Princeton University Press.

Hilsum, L. (2009). Chinese pay toxic price for a green world. *The Times.* Retrieved from http://www.timesonline.co.uk/tol/news/world/asia/article6946038.ece

Hitachi. (2012). Hitachi Metals Files Complaint in the ITC for the Infringement of Sintered Rare Earth Magnet Patents. Retrieved from https://www.hitachi-metals.co.jp/e/press/pdf/2012/20120820.pdf

Hoenderdaal, S., Tercero Espinoza, L., Marscheider-Weidemann, F., & Graus, W. (2013). Can a dysprosium shortage threaten green energy technologies?. *Energy*, *49*, 344-355.

Hong, F. (2001). Woguo Xitu Hangye Dangqian Cunzai de Zhuyao Wenti [Major Issues in Current Chinese Rare Earth Industry]. *Sichuan Xitu [Sichuan Rare Earths]*, *4*, 6-7.

Hong, F. (2006). Rare Earth: Production, Trade and Demand. *Journal of Iron and Steel Research, International*, *13*, 33-38.

Hornby, L. (2015, July 29). China protests over Fanya liquidity freeze could spread to banks. *Financial Times.* Retrieved from http://www.ft.com/intl/cms/s/0/05e1d638-3502-11e5-b05b-b01debd57852.html

Howell, S, Lee, H., & Heal, A. (2014). Leapfrogging or Stalling Out? Electric Vehicles in China. *Faculty Research Working Paper Series.* Cambridge, MA: Belfer Center for Science and International Affairs, Harvard Kennedy School. Retrieved from http://belfercenter.ksg.harvard.edu/publication/24335/leapfrogging_or_stalling_out_electric_vehicles_in_china.html

Howell, J. (2006). Reflections on the Chinese state. *Development and Change*, *37*(2), 273-297.

Hsueh, R. (2011). *China's Regulatory State: A New Strategy for Globalization*. Ithaca, NY: Cornell University Press.

Hsueh, R. (2012). China and India in the age of globalization: Sectoral variation in postliberalization reregulation. *Comparative Political Studies*, *45*, 32-61.

Hu, H., Wu, J. & Huang, Z. (2010). Lun Woguo Xiyou Youse Jinshu Chanye Jiegou Tiaozheng [On the Adjustment of Sectoral Structure of China's Rare Non-ferrous Metals Sector]. *Jiangxi Youse Jinsu [Jiangxi Non-ferrous Metals]*, *24* (3-4), 14-16 & 45.

Hu, J. (2006). Zou Zhongguo Tese Zizhu Chuangxin Daolu Wei Jianshe Chuangxin Xing

Guojia er Fendou [Fostering Indigenous Innovation with Chinese Characteristics and Striving to Construct Innovation-oriented Country]. Speech at the 1st Chinese Science and Technology Congress. Retrieved from http://theory.people.com.cn/GB/49169/49171/4012810.html

Hu, S. (1997). Woguo Jinqi Touzi Zhuti Yiyuan Fenxi [Analayis of Major Investors in Recent Period in China]. *Jingji Yanjiu Cankao [Review of Economic Research], 5,* 11-12.

Hu, S. (2012, April 9). Xitu Hangye Xiehui Guapai Zhongdian Buzai Kuangchan Kaifa [Rare Earth Industry Association Established with Focus Not on Mining Deposit Development]. *Dongfang Zaobao [Dongfang Daily]*, p. A20.

Hu, Y. (2013, June 28). Baotou “Xitu Xuanhu” zhi Kun Youwang Xiaochu [Baotou’s Trouble of Rare Earth Tailings Lake Could be Eliminated]. *Zhongguo Huagong Bao [China Chemical Industry News]*. Retrieved from http://www.ccin.com.cn/ccin/news/2013/06/28/267255.shtml

Hua, K. (1978, March 10). Unite and Strive to Build a Modern, Powerful, Socialist Country. *Peking Review*, 10, 7-40.

Huang, K. (1983, December 2). Guanyu <<Zhonghua Renmin Gongheguo Zhuanlifa (Cao’an)>> de Shuoming [Explanation about the Draft of the Patent Law of the People’s Republic of China]. Presentation at the 3rd Meeting of the Standing Committee of the 6th National People’s Congress. Retrieved from http://www.npc.gov.cn/wxzl/gongbao/2000-12/26/content_5001493.htm

Huang, X., Li, H., Xue, X. & Zhang, G. (2006). Woguo Xitu Shifa Yejin Fazhan Zhuangkuang ji Yanjiu Jingzhan [Development Status and Research Progress in Rare Earth Hydrometallurgy in China]. *Zhongguo Xitu Xuebao [Journal of the Chinese Rare Earth Society]*, 2, 129-133.

Huang, Y. (1996). Central-local relations in China during the reform era: the economic and institutional dimensions. *World Development*, *24*(4), 655-672.

Huang, S. (2007, May 29). Ganzhou Longjing He Liuyu Shangyou Cai Xitu Xiayou Shou Wuran [Upstream of Longjing River in Ganzhou Conducts Mining; Downstream Gets Pollution]. *Zhongguo Kuangye Bao [China Mining]*, p.C1.

Huang, Y. (2008). *Capitalism with Chinese characteristics: Entrepreneurship and the state* (Vol. 1). Cambridge: Cambridge University Press.

Huang, J. (2016, January 1). Zhongguo Nanfang Xitu Jituan Zujian Wancheng [South China Rare Earth Group Finished Registration]. *Jiangxi Ribao [Jiangxi Daily],* Retrieved from http://jx.people.com.cn/n2/2016/0101/c190181-27446028.html

Humphries, M. (2011). *Rare Earth Elements: the Global Supply Chain*. Washington, DC: Congressional Research Service.

Humphries, M. (2013). *Rare Earth Elements: the Global Supply Chain*. Washington, DC: Congressional Research Service.

Hurst, C. (2010, March). *China's Rare Earth Elements Industry: What can the West Learn?* Washington, DC: Institute for the Analysis of Global Security. Retrieved from http://www.iags.org/rareearth0310hurst.pdf

International Energy Agency (IEA). (2013a). *Tracking Clean Energy Progress 2013.* Paris, France: IEA.

International Energy Agency (IEA). (2013b). *Global EV Outlook.* Paris, France: IEA.

International Monetary Fund (IMF). (2006). The Development of China's Export Performance. Retrieved from https://www.imf.org/external/np/speeches/2006/030706.htm

Ito, K. (2010, August 29). レアアース輸出枠、中国側は削減緩和に応じず平行線－日中経済対話 [Against Japan's Wishes, China's Rare Earth Export Reduction Unlikely to be Weakened – Sino-Japan Economic Dialogue]. *Bloomberg Japan.* Retrieved from http://www.bloomberg.co.jp/news/123-L7WCTY07SXKX01.html

J-CAST News. (2010, September 15). レアアースで中国に「なめられた」経団連大臣欠席、次官も早々に会議から退席 [China Played around Japan-China Economic Association regarding Rare Earths: Prime Minister Absent, Vice Minister Also Left Meeting Early]. Retrieved from http://www.j-cast.com/2010/09/15075727.html

Jackson, W.D. & Christiansen, G. (1993). *International Strategic Minerals Inventory Summary Report: Rare-Earth Oxides.* Retrieved from http://pubs.usgs.gov/circ/1993/0930n/report.pdf

Japan Times. (2012, April 12). *Hitachi Builds Motors Without Rare Earth Metals.* Retrieved from http://www.japantimes.co.jp/text/nb20120412b1.html

Jacoby, M. & Jiang, J. (2010, August 30). Securing the Supply of Rare Earths. *Chemical & Engineering News*, *88*(35), 9-12.

Ji, L. (2004). Wanshan Xitu Chanpin Chukou Pei'e Guanli Zhidu Cujin Xitu Chanye Fazhan [Improve the Institutions of Managing Rare Earth Product Export Quota to Promote the Development of the Rare Earth Industry]. *Xitu Xinxi [Rare Earth Information],* 5, 16-17.

Jia, H. & Di, L. (2009, April). Xu Guangxian: a Chemical Life. *Chemical World.* London: Royal Society of Chemistry. Retrieved from http://www.rsc.org/chemistryworld/Issues/2009/April/XuGuangxianAChemicalLife.asp

Jiang, Z. (1999). Jiang Zemin Zongshuji Guanyu Xitu Gongzuo de Zhongyao Zhishi [General Secretary Jiang Zemin's Important Directive on Rare Earth Industry]. *Xitu Xinxi [Rare Earth Information]*, 5, 2-3.

Jiang, R. (2003, December 1). 2004 Nian Difang Zhengji Kaohe: Haiyou bi Difang GDP Geng Zhongyao de Shi – Fang Guojia Fagaiwei Hongguan Jingji Yanjiuyuan Fuyuanzhang Chen Dongqi [2004 Local Cadre Evaluation: Some Things More Important than Local GDP – Interview with Vice President of Macroeconomic Research Institute of the National Development and Reform Commission Chen Dongqi]. *Zhongguo Jingying Bao [China Business]*, p.2.

Jiang, X. (2012). *Woguo Kuangchan Ziyuan Chanquan Zhidu Gaige: Lilun yu Shijian [Reform of China's Mineral Resources Property Rights Institution: Theory and Practice]*. Beijing: Zhongguo Jingji Chubanshe [China Economic Publishing House].

Jiji Press. (2010, September 23). 日本向けレアアースを全面禁輸＝中国、尖閣沖衝突問題で－米紙[Japan faces complete rare earth ban from China due to Senkaku dispute – U.S. newspaper reports]. Retrieved from http://jp.wsj.com/layout/set/article/content/view/full/107641

Johnson, C. (1982). *MITI and the Japanese Miracle: The Growth of Industrial Policy: 1925-1975.* Stanford, CA: Stanford University Press.

Johnston, A. I. (2013). How new and assertive is China's new assertiveness? *International Security*, *37*(4), 7–48.

Kato, Y., Fujinaga, K., Nakamura, K., Takaya, Y., Kitamura, K., et al. (2011). Deep-sea Mud in the Pacific Ocean as a Potential Resource for Rare-earth Elements. *Nature Geoscience*, *4*(8), 535-539.

Kawamoto, H. (2008). Japan's policies to be adopted on rare metal resources. *Science & Technology Trends Quarterly Review, 27*, 57-76. Retrieved from http://www.nistep.go.jp/achiev/ftx/eng/stfc/stt027e/qr27pdf/STTqr2704.pdf

Kim, T-S. (2012, August). *Hangguo Xiyou Jingshu (Baokuo Xitu Yuansu) de Gongye ji Zhanlue [South Korea's Rare Metals (including Rare Earth Elements) Industry and Strategy]*. Paper presented at the 4th Baotou International Rare Earth Industry Conference, Baotou, China.

Kingsnorth, D. (2009). *Meeting Demand in 2014: The Critical Issues.* Presentation at the 5th International Rare Earth Conference, Hong Kong.

Kitschelt, H. (1991). Industrial Governance Structures, Innovation Strategies, and the Case of Japan: Sectoral or Cross-National Comparative Analysis? *International Organization, 45*(4), 453–493.

Krugman, P. (2010, October 18). Rare and Foolish. *New York Times*, p. A35.

Lam, J. (2012). Malaysia: Rare Earth Processing Plant Creates Backlash. Retrieved from http://globalvoicesonline.org/2012/04/27/malaysia-rare-earth-processing-plant-creates-backlash/

Lardy, N. (1998). *China's Unfinished Economic Revolution.* Washington, DC: Brookings Institution.

Levkowitz, L. & Beauchamp-Mustafaga, N. (3 November, 2010).*China's rare earths industry and its role in the international market*. U.S.–China Economic and Security Review Commission Staff Backgrounder. Washington, D.C.: U.S.-China Economic and Security Review Commission.

Li, G. (2010, December 2). An Cang Shengtai Zhadan: Baotou Xitu Hu Diaocha [Hidden Ecological Bomb: Investigation of Baotou Rare Earth Lake]. *Meiri Jingji Xinwen*

[National Business Daily]. Retrieved from http://old.nbd.com.cn/newshtml/20101202/20101202013309187.html

Li, P. (1984). Caikuangye Shixing “Da Kuang Da Kai” “You Shui Kuai Liu” De Tantao [Discussion on the “Large Production at Large Mines” and “Rapid Production when Resources are Present” in the Mining Industry]. *Jingji Guanli [Economic Management]*, 10, 6-8.

Li, P. (1991). *Guanyu Guoming Jingji He Shehui Fazhan Shinian Guihua He Di Ba Ge Wunian Jihua Gangyao De Baogao [Report on the 10 Year Plan of National Economy and Social Development and the 8th Five-Year Plan Brief]*. Retrieved from http://news.xinhuanet.com/ziliao/2005-02/17/content_2587910.htm

Li, Y. (2005). *Xitu Ziyuan Zonghe Liyong Ji Chanyehua Zhuanli Zhanlue Yanjiu (Research on the Patent Strategies of Integrated Use and Commercialization of Rare Earth Resource).* Hohhot, Inner Mongolia: Bureau of Intellectual Property of the Inner Mongolia Autonomous Region Government. Retrieved from http://www.sipo.gov.cn/dtxx/zlgzdt/2006/200804/t20080419_385245.html

Li, J. & Liu, J. (2009, September 7). Rare earth industry adjusts to slow market. *China Daily.* Retrieved from http://www.chinadaily.com.cn/bw/2009-09/07/content_8660849.htm

Li, B. (2010). *Development of Chinese Rare Earth Permanent Magnets*. Beijing: China Iron & Steel Research Institute.

Li, J. (2011, October 25). “Fengkuang Xitu” Beihou de Liyi Boyi [Crazy Game behind the Craze of Rare Earths]. *Zhongguo Qingnian Bao [China Youth Daily]*, p.4.

Li, R. (2012). Shierwu Keji Zhuanxiang Xiang Xituye Tou 3.5 Yi [Rare Earth Industry Allocated 350 billion RMB funding in Science and Technology Component of the12th Five-Year Plan]. *Zhongguo Zhengquan Bao [China Securities Journal]*. Retrieved from http://www.cnfol.com/site/zqbk/cs.htm

Li, Y. (2012). Lun Fenquan Beijing Xia de Zhongguo Chuizhi Guanli Zhi [A Preliminary Study of Chinese Vertical Management System]. *Jingji Shehui Tizhi Bijiao [Comparative Economic and Social Institutions]*, 4, 211-219.

Li, Z. & He, X. (2012). Gannan Xitu Chanye Zhuanxing Fazhan yu Shengtai Xiufu Wenti Yanjiu [Research on the Changing Model of Development of the Rare Earth

Industry and Ecological Restoration in Gannan]. Paper presented at the 8th Annual Conference of Chinese Ecological Economics Society & Forum on Ecological Economics and Changing Model of Economic Development.

Li, Z. (2015, August 26). Jijian Jiancha Paizhu Jigou Lishi Yange [Historical Trajectory of the Dispatched Discipline Inspection and Supervision Institution]. *Zhongguo Jijian Jiancha Bao [China Discipline Inspection and Supervision News],* p.3.

Liao, J. & Li, R. (2008, June 12). Guanyu Jijian Jiancha Jiguan Zhaoshang Yinzi Wenti de Diaocha [Report on the Issue of Discipline Inspection and Supervision Institutions involved in Attracting Economic Development and Investment Projects]. Research Office of the Hubei Province Discipline Inspection Committee.

Liao, X. (2002). 1962 Nian Guangzhou Huiyi de Qianqian Houhou [Historical Events Surrounding the 1962 Guangzhou Conference]. *Dang De Wenxian [Party Literature]*, 2, 13-21.

Lieberthal, K.G. & Lampton, D.M. (1992). *Bureaucracy, Politics, and Decision-Making in Post-Mao China.* Berkeley, CA: University of California Press.

Lin, J. Y. (1988). The household responsibility system in China's agricultural reform: a theoretical and empirical study. *Economic Development and Cultural Change*, S199-S224.

Lin, J. Y., Cai, F. & Li, Z. (2003). *The China Miracle: Development Strategy and Economic Reform.* Hong Kong: Chinese University Press.

Lin, K.C. (2008). Macroeconomic Disequilibria and Enterprise Reform: Restructuring the Chinese Oil and Petrochemical Industries in the 1990s. *The China Journal*, 60, 49-79.

Lin, W. (2012, November 19). 1988 Nian de Nengyuanbu Shijian Weishenme Shibai [Why the 1988 Ministry of Energy Experiment Failed]. *Zhongguo Nengyuan Bao [China Energy News]*, p.01. Retrieved from http://paper.people.com.cn/zgnyb/html/2012-11/19/content_1146956.htm

Liu, G. (2010, March 22). Xitu Daocai Zhi Shang [Peril of Illegal Rare Earth Mining]. *Jiangnan Dushi Bao [Jiangnan Metropolitan News]*, p. A08.

Liu, H. & Liu, Z. (2012, August 20). Xitu Wuran Ganzhou [Rare Earths Pollution in Ganzhou]. *Caixin Century Weekly,* pp. 82-84.

Liu, J. P. (1989, October 31). Xitu Gu – 21 Shiji de Gaokeji Chanye [Rare Earth Valley – High-tech Industry Sector of the 21st Century]. *Keji Ribao [Science and Technology Daily]*.

Liu, J. P. (2014). Xitu Yuan [Serendipity with Rare Earths]. *Ningbo Institute of Material Technology and Engineering Today, 1*(3), 2-9.

Liu, L. (2008, February 20). Yangqi Zhenghe Bufa Jinnian Tisu: Dao 2010 Nian Yao Chongzu 1/2 Zhi 2/3 [SOE Consolidation on Fast Track This Year: Restructuring 1/2-2/3 by 2010]. *Zhengquan Ribao [Securities Daily]*, p. A02.

Liu, S. (1987). Riben 1985 Nian Xitu Jinkouliang Zhongguo Zhan Shouwei [China Ranks the First in Japan's Rare Earth Import in 1985]. *Shanghai Jinshu [Shanghai Metals]*, 1, 61-62.

Liu, S. (1992). Faguo Luona Pulangke Gongsi Jiasu Goumai Daliang Zhongguo Xitu Yuanliao [French company Rhone-Poulenc to Increase Rare Earth Raw Materials Import from China]. *Xitu Xinxi [Rare Earth Information]*, 4, 10.

Liu, S. & Li, H. (2014). Shuangchong Lingdao yu Duorenwuxing: Zhongguo Xiangzhen Jijian Jiancha Zuzhi Jiandu Kunjing de Shizheng Yanjiu [Dual Management and Multi-tasking: Empirical Research on the Supervision Dilemma in China's Rural Discipline Inspection and Supervision Institutions]. *Gonggong Xingzheng Pinglun [Journal of Public Administration]*, 3, 107-132.

Liu, W. & Yao, X. (Eds.). (2004). *Zhongguo Xitugu Xilie Congshu: Jiqing Suiyue [China's Rare Earth Valley Book Series: Years of Passion].* Hohhot, Inner Mongolia: Yuanfang Chubanshe [Faraway Press].

Liu, Y. & Guo, F. (1993). Jiangxi Xitu Gongye de Huigu he Zhanwang [Review and Insight into the Rare Earth Industry in Jiangxi]. *Jiangxi Youse Jingshu [Jiangxi Nonferrous Metals]*, *7*(2), 86-88.

Liu, Y. (2002). Xitu Kaicai Gongyi Gaijin hou de Shuitu Liushi Xianzhuang he Shuitu Baochi Duice [Present Conditions of Soil & Water Loss and Countermeasures of Soil & Water Conservation after Improving Rare-earth Mining Technology]. *Shuili Fazhan Yanjiu [Water Resources Development Research]*, *2* (2), 30-32.

Liu, Y. (2007, June). Zhongguo Xitu Chanye Xianzhuang ji Fazhan de Zhuyao Renwu [Current Situation and Major Tasks of China's Rare Earth Industry Development]. *Zhongguo Xitu Xuebao [Journal of the Chinese Rare Earth Society]*, *25* (3), 257-262.

Liu, Y. (2010). Wukuang Zheng Gan Enchou Ji [Tale of China Minmetal's Battle in Jiangxi]. *Zhongguo Jingji he Xinxihua [China Economy & Informatization]*, 21, 32-37.

Liu, Y. (2011). Zhongguo Xitu Chukou de Xianzhuang yu Weilai [Current Situation and Future of China's Rare Earth Export]. Paper presented at the 4th Baotou Rare Earth Industry International Forum.

Long, K.R., Van Gosen, B.S., Foley, N.K., & Cordier, D. (2010). *The principal rare earth elements deposits of the United States—A summary of domestic deposits and a global perspective*. U.S. Geological Survey Scientific Investigations Report 2010–5220, 96 p. Retrieved from http://pubs.usgs.gov/sir/2010/5220/.

Long, K.R. (2011). *The future of rare earth elements: will these high-tech industry elements continue in short supply?* U.S. Geological Survey Open-File Report 2011-1189, 41 p. Retrieved from http://pubs.usgs.gov/of/2011/1189/.

Lü, X. (2000). *Cadres and Corruption: The Organizational Involution of the Chinese Communist Party.* Stanford, CA: Stanford University Press.

Ma, P. (1995). 1989-1993 Zhongguo Xitu Gongye [1989-1993 China's Rare Earth Industry]. *Xitu [Rare Earths]*, *16* (3), 37-42.

Ma, P. (2000). Fang Yi Tongzhi Qi Xia Baotou Zhua Baiyun Ebo Ziyuan Zonghe Liyong [Comrade Fang Yi's Seven Visits to Baotou to Work on Comprehensive Use of Baiyun-Ebo Resources]. *Xitu Xinxi [Rare Earth Information]*, 10, 2-6.

Ma, X., Lu, W. & Yu, S. (2001). Xitu Chanye Kechixu Fazhan Huanjing Jingji Duice [The environmental and economic countermeasures of the sustainable rare earth industry]. *Neimenggu Huanjing Baohu [Inner Mongolia Environmental Protection]*, *13*(4), 44-46.

Ma, P. (2012). *Xitu Baogao Wenji [Rare Earth Report Collections]*. Beijing: Yejing Gongye Chubanshe [Metallurgical Industry Press].

MacFarquhar, R., & Schoenhals, M. (2006). *Mao's last revolution* (pp. 153-68). Cambridge: Cambridge University Press.

Mancheri, N., Sundaresan, L. & S. Chandrashekar. (2013). *Dominating the World: China and the Rare Earth Industry* (No. R19-2013). Bangalore, India: National Institute of Advanced Studies.

Manion, M. (1985). The cadre management system, post-Mao: The appointment, promotion, transfer and removal of party and state leaders. *The China Quarterly*, *102*, 203-233.

Mao, Z. (1925). Zhongguo Shehui Ge Jieji De Fenxi [Analysis on the Social Classes in Chinese Society]. In Jiang (ed.), *Mao Zedong Zhuzuo Xuan [Selected Works of Mao Zedong]*. Hong Kong: Shangwu Yinshuguan [Commercial Press Hong Kong].

Mao, Z. (1957). Mao Zedong Zai Zhonggong Bajie Sanzhong Quanhui Bimu Hui Shang De Jianghua Jilu [Mao Zedong's Speech at the Closing Ceremony of the 3rd Plenary Session of the 8th CPC Party Congress Meeting]. Retrieved from http://cpc.people.com.cn/GB/69112/70190/70192/4765771.html

Margonelli, L. (2009). Clean Energy's Dirty Little Secret. *The Atlantic.* Retrieved from http://www.theatlantic.com/magazine/archive/2009/05/clean-energys-dirty-little-secret/307377/

Matsuo, M. (2010, September 23). 中国が日本向けレアアース全面禁輸 尖閣沖衝突問題で、米紙報道 [China Blocks Rare Earth Export to Japan Due to Senkaku Island Dispute, U.S. Media Reports]. Retrieved from http://sankei.jp.msn.com/politics/news/110123/plc11012309070108-n1.htm

MIT Energy Initiative, APS and MRS. (2010, April 29). *Critical Elements for New Energy Technologies. An MIT Energy Initiative Report.* Cambridge, MA: MIT Energy Initiative.

McAdam, D., Tarrow, S. & Tilly C. (2001). *Dynamics of Contention*. Cambridge: Cambridge University Press.

Mertha, A. C. (2005). *The Politics of Piracy: Intellectual Property in Contemporary China.* Ithaca, NY: Cornell University Press.

Miao, W. (2009, August). Xitu Chanye Fazhan Zhi Lu Renzhong Er Daoyuan [Rare Earth Industry Development: Great Responsibilities and Long Way to Go]. *Zhongguo Gaoxinqu [China High-Tech Zone]*, 14-15.

Migdal, J. S. (1988). *Strong societies and weak states: state-society relations and state capabilities in the Third World*. Princeton, NJ: Princeton University Press.

Ministry of Economy, Trade and Industry of Japan (METI). (2009). *Announcement of "Strategy for Ensuring Stable Supplies of Rare Metals".* Retrieved from http://www.meti.go.jp/english/press/data/20090728_01.html

Ministry of Economy, Trade and Industry of Japan (METI). (2010, October 5). *中国における輸出入状況に関する調査結果について[Results of Survey on China's Export and Import Situation]*. Tokyo: METI. Retrieved from http://www.cmaj.jp/news/view/385

Ministry of Economy, Trade and Industry of Japan (METI). (2012). *レアアース・レアメタル使用量削減・利用部品代替支援事業 [Support for Usage Reduction and Substitution of Rare Earth Rare Metals]*.Tokyo: METI.

Ministry for Foreign Affairs of Japan & Ministry for Foreign Affairs of the People's Republic of China. (1972). *Joint Communique of the Government of Japan and the Government of the People's Republic of China*. Retrieved from http://www.mofa.go.jp/region/asia-paci/china/joint72.html

Montinola, G., Qian, Y. & Weingast, B.R. (1995). Federalism, Chinese Style: The Political Basis for Economic Success in China. *World Politics, 48*(1), 50-81.

Morrison, W. M., & Tang, R. (2012). *China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States*. Congressional Research Service, Library of Congress.

Moss, R. L., Tzimas, E., Kara, H., Willis, P., & Kooroshy, J. (2011). *Critical Metals in Strategic Energy Industries.* Luxemburg: European Commission Joint Research Centre-Institute for Energy and Transport. Retrieved from http://setis.ec.europa.eu/system/files/CriticalMetalsinStrategicEnergyTechnologies-def.pdf

Nakano, J. (2011). Rare Earth Trade Challenges and Sino-Japanese Relations: A Rise of Resource Nationalism. In M.E. Herberg (Ed.), *Asia's Rising Energy and Resource Nationalism: Implications for the United States, China, and the Asia-Pacific* Region (pp. 53-65). Washington, D.C.: National Bureau of Asian Research.

Nanfang Daily. (2005). Shui Wei Shengcun Huanjing Maidan: Guangdong Sheng Xinning Shi Zoutao Cun 20 Nian Baoshou Xitu Kaicai Wuran Zhi Ku [Who Pays for Living Environment: Zoutao Village in Xinning Prefecture, Guangdong Province Suffered Pollution from Rare Earth Mining for 20 Years]. *Xitu Xinxi [Rare Earth Information]*, 4, 34-35.

Naughton, B. (1994). What is distinctive about China's Economic Transition? State Enterprise Reform and Overall System Transformation. *Journal of Economic Literature*, *18*, 470-490.

Naughton, B. (1996). *Growing out of the plan: Chinese economic reform, 1978-1993*. Cambridge: Cambridge university press.

Naughton, B. J. & Yang D. (2004). *Holding China Together: Diversity and National Integration in the Post-Deng Era.* Cambridge: Cambridge University Press.

Naughton, B. (2009). Understanding the Chinese Stimulus Package. *China Leadership Monitor.* Retrieved from http://www.hoover.org/research/understanding-chinese-stimulus-package

Navigant Research. (2015). *World Wind Energy Market Update 2015*. Chicago, IL: Navigant Research.

Ni, J. & Hong, G. (eds.) (2005). *Zhongguo Kexueyuan Xitu Yanjiu Wushi Nian [Fifty Years of Rare Earth Research at the Chinese Academy of Science]*. Beijing: Kexue Chubanshe [Science Press].

Nie, R. (1960). *Guanyu Baotou Xitu Hejinggang Shiyan Shiyong he Gangtie Shengchan Wenti [Issue about Baotou Rare Earth Alloyed Steel Experimental Use and Steel Production]*. Retrieved from http://nrzsjk.com/News/GetStatic/zzlz/kjwx/2010-06/20101811111822.html

Nie, R. (1999). *Nie Rongzhen Keji Wenxuan [Nie Rongzhen's Science and Technology Essays]*. Beijing: Guofang Gongye Chubanshe [Defense Industry Press].

Nikkei. (2012, January 6). レアアース巡り日中官民が協議会 安定供給求める[Sino-Japan rare earth conference for both government and private sector seeks secure supply]. Retrieved from http://www.nikkei.com/article/DGXNASFS0501Q_V00C12A1EE2000/

Nikkei. (2014, June 6). TDK to make magnets for hybrids in China. Retrieved from http://asia.nikkei.com/Business/Companies/TDK-to-make-magnets-for-hybrids-in-China

Office of Shanghai Chronicles. (1999). *Shanghai Youse Jingshu Gongye Zhi [Shanghai Non-ferrous Metals Industry Chronicle]*. Shanghai: Shanghai Shehui Kexue Chubanshe [Shanghai Social Science Press]. Retrieved from http://www.shtong.gov.cn/node2/node2245/node4497/index.html

Oi, J. C. (1992). Fiscal reform and the economic foundations of local state corporatism in China. *World Politics*, *45*(01), 99-126.

Oi, J. C. (1995). The role of the local state in China's transitional economy. *The China Quarterly*, *144*, 1132-1149.

Oi, J.C. (1999). *Rural China Takes Off: Institutional Foundations of Economic Reform.* Berkeley, CA: University of California Press.

Ouyang, Y. (2009). Zhongguo Xitu Zhi Fu Jianyi Yong Shiyi Meiyuan Waihui Goumai Chubei Xitu [Father of China’s Rare Earth Recommends Using 1 Billion Dollar Reserve to Stockpile Rare Earths]. *Zhongguo Jingji Shibao [Chinese Economic Times]*. Retrieved from http://www.cet.com.cn/20091029/h1.htm.

Park, A., Rozelle, S., Wong, C., & Ren, C. (1996). Distributional consequences of reforming local public finance in China. *The China Quarterly*, *147*, 751-778.

Peng, D. (2005). Gannan Xitu Kuang Shuitu Liushi Tedian ji Fangzhi Jishu [Characteristics of Soil and Water Erosion in Gannan Rare Earth Mining and Preventive Technical Solutions]. *Yaredai Shuitu Baochi [Subtropical Soil and Water Conservation], 17* (3), 14-15.

Permanent Mission of China to the WTO. (2011). China in the WTO: Past, Present and Future. Retrieved from https://www.wto.org/english/thewto_e/acc_e/s7lu_e.pdf

Piesing, M. (2013, July 31). Rare-earth Mineral Substitutes could defeat Chinese stranglehold. *Wired*. Retrieved from http://www.wired.co.uk/news/archive/2013-07/31/race-for-rare-earth-minerals

PRC Commission for Science, Technology and Industry for National Defense (COSTIND). (1988). *Guanyu Cujing Jungong Jishu Xiang Minyong Zhuanyi he Zuzhi Jungong Liliang wei Yanhai Diqu Jingji Fazhan Zhanlue Fuwu de Jianyi [Recommendation on Improving the Transition of Military Technologies towards Civilian Use and Organizing Military Technology Units to Serve Economic Development Strategies in Coastal Areas]*. Retrieved from http://www.gov.cn/zhengce/content/2012-02/02/content_3193.htm

PRC Commission for Science, Technology and Industry for National Defense (COSTIND). (1997). *Guanyu Jiaqiang Jungong Keyan Yuansuo yu Qiye Jiehe Jinyibu Cujin Junzhuanmin Gongzuo de Ruogan Yijian [Several Opinions on Enhancing the Integration of Military Technology Research Institutes and Enterprises and Further Promoting the Transition of Military Technologies towards Civilian Use]*. Retrieved from http://www.nmgzfgb.gov.cn/information/nmgzb19/msg675798661.html

PRC Information Office. (2012). *Situation and Policies of China's Rare Earth Industry.* Beijing. Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n12771663/n14676956.files/n14675980.pdf

PRC Ministry of Commerce (MOFCOM). (2005a). *Shangwubu Gonggao 2005 Nian Di 119 Hao 2006 Nian Xitu Chukou Qiye Mingdan [Announcement No. 119 [2005] of the Ministry of Commerce – Announcement of the List of Rare Earth Export Companies in 2006]*. Beijing.

PRC Ministry of Commerce (MOFCOM). (2005b). *Shangwubu Haiguan Zongshu Gonggao 2005 Nian Di 26 Hao – Lieru Jiagong Maoyi Jinzhi Lei de Shangpin Mulu [Announcement No.26 [2005] of the Ministry of Commerce and General Administration of Customs--Publicizing Forbidden Commodity Catalogue of Processing Trade]*. Beijing.

PRC Ministry of Commerce (MOFCOM), General Administration of Customs & General Bureau of Environmental Protection. (2007). *2007 Nian JIagong Maoyi Jinzhi Lei Shangpin Mulu [2007 Year Forbidden Commodity Catalogue of Processing Trade]*. Beijing.

PRC Ministry of Commerce (MOFCOM). (2008). *Shangwubu Gonggao 2008 Nian Di 107 Hao 2009 Nian Xitu Chukou Qiye Mingdan [Announcement No. 107 [2008] of the Ministry of Commerce – Announcement of the List of Rare Earth Export Companies in 2009]*. Beijing.

PRC Ministry of Commerce (MOFCOM). (2011). *Shangwubu Gonggao 2011 Nian Di 77 Hao Gongbu Guanyu 2012 Nian Xitu Chukou Pei'e Shenbao Tiaojian he Shenbao Chengxu [Announcement No.77 [2011] of the Ministry of Commerce -- Announcement on Application Conditions and Procedures of Export Quota of Rare Earth in 2012]*. Retrieved from http://www.mofcom.gov.cn/aarticle/b/g/201201/20120107919914.html

PRC Ministry of Commerce (MOFCOM). (2014, December 31). *Shangwubu Haiguan Zongshu Gonggao 2014 Nian Di 94 Hao Gongbu 2015 Nian Chukou Xukezheng Guanli Huowu Mulu [Announcement No. 94 [2014] of the Ministry of Commerce and General Administration of Customs—Catalogue of Products under the Administration of Export Licenses for Year 2015]*. Retrieved from http://www.mofcom.gov.cn/article/b/c/201412/20141200854859.shtml

PRC Ministry of Environmental Protection (MEP). (2009). *<<Xitu Gongye Wuranwu Paifang Biaozhun>> Bianzhi Shuoming [Explanation on Drafting the Emission Standards of Pollutants from Rare Earth Industry]*. Retrieved from http://www.sepa.gov.cn/info/bgw/bbgth/200907/W020090713562804335545.pdf

PRC Ministry of Environmental Protection (MEP). (2011a). *Xitu Gongye Wuranwu Paifang Biaozhun [Emission Standards of Pollutants from Rare Earth Industry]*. Retrieved from http://www.mep.gov.cn/gkml/hbb/bgg/201101/W020120113571541908558.pdf

PRC Ministry of Environmental Protection (MEP). (2011b, April 20). *Guanyu Jiaqiang Xitu Kuangshan Shengtai Baohu yu Zhili Huifu de Yijian [Opinions on Strengthening the Protection, Treatment and Restoration of the Ecological Environment of Rare Earth Mines]*. Retrieved from http://report.hbepb.gov.cn:8080/pub/root8/hbtwj/201107/t20110722_46029.html

PRC Ministry of Environmental Protection (MEP). (2011c, August). *Xitu Huanjing Baohu Hecha Gongzuo Zhinan [Rare Earth Environmental Protection Inspection Manual]*. Beijing.

PRC Ministry of Environmental Protection (MEP). (2011d, November 22). *Guanyu Fabu Fuhe Huanbao Yaoqiu de Xitu Qiye Mingdan de Gonggao (Diyi Pi)*

[Announcement of Rare Earth Companies Compliant with Environmental Protection Requirements (1st Batch)]. Retrieved from http://www.mep.gov.cn/gkml/hbb/bgg/201111/t20111124_220527.htm

PRC Ministry of Environmental Protection (MEP). (2012a, May 10). *Guanyu Fabu Fuhe Huanbao Yaoqiu de Xitu Qiye Mingdan de Gonggao (Di'er Pi) [Announcement of Rare Earth Companies Compliant with Environmental Protection Requirements (2nd Batch)]*. Retrieved from http://www.mep.gov.cn/gkml/hbb/bgg/201205/t20120516_229506.htm

PRC Ministry of Environmental Protection (MEP). (2012b, August 16). *Guanyu Fabu Fuhe Huanbao Yaoqiu de Xitu Qiye Mingdan de Gonggao (Disan Pi) [Announcement of Rare Earth Companies Compliant with Environmental Protection Requirements (3rd Batch)]*. Retrieved from http://www.mep.gov.cn/gkml/hbb/bgg/201208/t20120820_234970.htm

PRC Ministry of Environmental Protection (MEP). (2013). *Guanyu Fabu Fuhe Huanbao Yaoqiu de Xitu Qiye Mingdan de Gonggao (Disi Pi) [Announcement of Rare Earth Companies Compliant with Environmental Protection Requirements (4th Batch)]*. Retrieved from http://wfs.mep.gov.cn/gywrfz/cytz/dbgg/201312/t20131206_264500.htm

PRC Ministry of Finance (MOF). (1985, March 12). *Caizhengbu Guanyu Guanyu Dui Jinchukou Shangpin Zheng Tui Chanpinshui Huo Zengzhishui de Guiding [Provisions of the Ministry of Finance for the Collection and Refund of Product Tax and Value Added Tax on Import and Export Products]*. Retrieved from http://www.gov.cn/zhengce/content/2013-09/06/content_2112.htm

PRC Ministry of Finance (MOF) & General Administration of Taxation. (2000). *Caizhengbu Guojia Shuiwu Zongju Guanyu Zhongyang Suoshu Youse Jinshu Qishiye Danwei Guanli Tizhi Gaige Hou Qiye Suodeshui Ruku Jici he Zhengshou Guanli Wenti de Tongzhi [Announcement of the Ministry of Finance and Generation Administration of Taxation on Corresponding Levels of Taxation and the Management of Corporate Income Tax after the Reform of the Management System of Central-Government-Owned Non-ferrous Metals Companies and Institutions]*. Retrieved from http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/caizhengbuwengao2000/caizhengbuwengao20008/200805/t20080519_21487.html

PRC Ministry of Finance (MOF) & General Administration of Taxation. (2005). *Guanyu Tiaozheng Bufen Chanpin Chukou Tuishuilv de Tongzhi [Announcement on Adjusting the Export Tax Rebate of Some Products]*. Beijing.

PRC Ministry of Finance (MOF). (2006a). *Caizhengbu Guanyu Shishi Cujin Zizhu Chuangxin Chanpin Zhengfu Caigou Zhengce de Ruogan Yijian [Advice of the Ministry of Finance on Improving the Government Procurement of Indigenous Innovation Products]*. Retrieved from http://www.ccgp.gov.cn/zcfg/mof/201311/t20131113_3591932.htm

PRC Ministry of Finance (MOF). (2006b). *Guanyu Tiaozheng Bufen Shangpin Jinchukou Zanding Shuilv de Tongzhi [Notice on Adjusting the Tentative Export and Import Tariff of Some Products]*. Beijing.

PRC Ministry of Finance (MOF). (2007). *Guanyu Tiaozheng Bufen Shangpin Jinchukou Zanding Shuilv de Tongzhi [Notice on Adjusting the Tentative Export and Import Tariff of Some Products]*. Beijing.

PRC Ministry of Finance (MOF). (2008). *Guanyu Tiaozheng Bufen Shangpin Jinchukou Zanding Shuilv de Tongzhi [Notice on Adjusting the Tentative Export and Import Tariff of Some Products]*. Beijing.

PRC Ministry of Finance (MOF). (2011). *Guanyu Tingzhi Zhixing <<Zizhu Chuangxin Chanpin Zhengfu Caigou Yusuan Guanli Banfa>> Deng Sange Wenjian de Tongzhi [Notice on Discontinuing the Implementation of Three Regulations including the Management of Government Procurement Budget for Indigenous Innovation Products]*. Retrieved from http://gks.mof.gov.cn/redianzhuanti/zhengfucaigouguanli/201106/t20110628_567649.html

PRC Ministry of Finance (MOF) & PRC Ministry of Industry and Information Technology (MIIT). (2012, November 9). *Xitu Chanye Tiaozheng Shengji Zhuanxiang Zijin Guanli Banfa [Regulation on Administrating the Special Fund for Rare Earth Industry Restructuring and Upgrading]*. Retrieved from http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/2012wg/wg201212/201302/t20130205_732223.html

PRC Ministry of Finance (MOF) & PRC Ministry of Industry and Information Technology (MIIT). (2014, May 30). *Guojia Wulianwang Fazhan ji Xitu Chanye Buzhu Zijing Guanli Banfa [Regulation on Administrating the Funding for National Supply Chain Network and Subsidy Funding for the Rare Earth Industry]*.Beijing.

PRC Ministry of Finance (MOF). (2015, April 14). *Guowuyuan Guanshui Shuize Weiyuanhui Guanyu Tiaozheng Bufen Chanping Chukou Guanshui de Tongzhi*

[Notice of the Customs Tariff Commission of the State Council on Adjustment of Export Tariff of Some Products]. Retrieved from http://gss.mof.gov.cn/zhengwuxinxi/zhengcefabu/201504/t20150423_1221830.html

PRC Ministry of Finance & State Administration of Taxation. (2015, April 30). *Guanyu Shishi Xitu, Wu, Mu Ziyuanshui Congjia Jizheng Gaige de Tongzhi [Notice of Implementation of the Price-Based Resource Tax on Rare Earths, Tungsten and Molybdenum]*. Retrieved from http://www.chinatax.gov.cn/n810341/n810755/c1591556/content.html

PRC Ministry of Foreign Economy and Trade & State Economic Commission. (1987). *Guanyu Xitu Chukou Wenti de Tongzhi [Notice on Issues in Rare Earth Export]*. Beijing.

PRC Ministry of Foreign Trade and Economic Cooperation. (1988). *1988 Nian Waimao Tizhi Gaige Fang'an [1988 Reform Plan of the Foreign Trade System].* Beijing.

PRC Ministry of Foreign Economy and Trade. (1992, April 21). *Duiwai Jingmao Bu Guanyu Xitu Chukou Guanli Banfa [Regulation on Rare Earth Export from the Ministry of Foreign Economy and Trade]*. Beijing.

PRC Ministry of Foreign Trade and Economic Cooperation. (1999, February 14). *Duiwai Maoyi Jingji Hezuobu Guanyu Xiada 1999 Nian Xitu Chanping Chukou Pei'e de Tongzhi [Notice of the Ministry of Foreign Trade and Economic Cooperation on Issuing the Export Quota for Rare Earth Products for the Year 1999]*. Retrieved from http://policy.mofcom.gov.cn/section/wto!fetch.action?lanmu=wm&id=G000073085

PRC Ministry of Heavy Industries. (1953). *Guanyu Baotou Gangtie Chang Ziyuan Gaikuang Ji Xuanze Changzhi Qingkuang De Baogao [Report on the Resources Available and Location Selection for the Baotou Iron Factory]*. Beijing.

PRC Ministry of Industry and Information Technology (MIIT). (2008). *2008 Nian Zhongguo Xitu Shijian Dashi [Top ten events in China's rare earth industry in 2008]*. Beijing.

PRC Ministry of Industry and Information Technology (MIIT). (2009). *<2012 Zhi 2015 Nian Xitu Gongye Fazhan Guihua> Xiudinggao [The 2009-2015 Plans for Developing the Rare Earth Industry (Revised Version)]*. Beijing: MIIT.

PRC Ministry of Industry and Information Technology (MIIT). (2009). *2009 Nian Zhongguo Xitu Shijian Dashi [Top ten events in China's rare earth industry in 2009]*. Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368277/13039967.html

PRC Ministry of Industry and Information Technology (MIIT), Ministry of Supervision, Ministry of Environmental Protection (MEP), State Administration of Taxation, State Administration for Industry and Commerce & State Administration of Work Safety. (2011, July 25). *Guanyu Kaizhan Quanguo Xitu Shengchan Zhixu Zhuanxiang Zhengzhi Xingdong de Tongzhi [Announcement of Organizing a National Special Campaign on Restoring Order in Rare Earth Production]*. Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n12843926/n13917027/14035175.html

P.R.C. Ministry of Industry and Information Technology. (MIIT). (2012a). *Xin Cailiao Chanye Shi'er Wu Fazhan Guihua (Development Plan of New Materials Industry in the 12th Five Year Plan).* Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/14470388.html

PRC Ministry of Industry and Information Technology (MIIT). (2012b, June 13). *Xitu Zhiling Xing Shengchan Jihua Guanli Zanxing Banfa [Interim Measures of Administration of the Mandate Production Plan of Rare Earths]*. Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n12843926/n13917027/n14690047.files/n14689773.doc

PRC Ministry of Industry and Information Technology (MIIT). (2012c). *Xitu Hangye Zhunru Tiaojian [Entry Criterion for Rare Earth Industry]*. Beijing: MIIT.

PRC Ministry of Industry and Information Technology (MIIT), Ministry of Public Security (MOPS), Ministry of Land and Resources (MLR), Ministry of Environmental Protection (MEP), General Administration of Customs, State Administration of Taxation, State Administration for Industry and Commerce & State Administration of Work Safety. (2013, August 5). *Guanyu Zuzhi Kaizhan Daji Xitu Kaicai, Shengchan, Liutong Huanjie Weifa Weigui Xingwei Zhuanxiang Xingdong de Han [Letter on Organizing a Special Campaign on Cracking down on Violations of Laws and Regulations during the Mining, Production and Circulation of Rare Earth]*. Retrieved from http://wap.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/15564503.html

PRC Ministry of Industry and Information Technology (MIIT). (2013, December 25). Neimenggu Baiyun-ebo Xitu Kuangqu Shixing Kuangqu Quan Fengbi Guanli [Baiyun-ebo Rare Earth Mining Region in Inner Mongolia Achieves Closed-off Management]. Retrieved from http://ycls.miit.gov.cn/n11293472/n11295125/n11299560/15786486.html

PRC Ministry of Industry and Information Technology (MIIT). (2014, August 18). *2014 Nian Gongye Hangye Taotai Luohou he Guosheng Channeng Qiye Mingdan (Di'er Pi) [List of Companies under Elimination of Backward and Excessive Production Capacities in the Industrial Sector in Year 2014 (Second Batch)]*. Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916898/16115614.html

PRC Ministry of Industry and Information Technology (MIIT), Ministry of Public Security (MOPS), Ministry of Land and Resources (MLR), Ministry of Environmental Protection (MEP), General Administration of Customs, State Administration of Taxation, State Administration for Industry and Commerce & State Administration of Work Safety. (2014, September 30). *Guanyu Zuzhi Kaizhan Daji Xitu Weifa Weigui Xingwei Zhuanxiang Xingdong de Han [Letter on Organizing a Special Campaign to Crack Down on Violations of Law or Regulation Regarding Rare Earth]*.Retrieved from http://www.miit.gov.cn/n11293472/n11293832/n12843926/n13917027/16160874.html

PRC Ministry of Industry and Information Technology (MIIT). (2015, February 3). *Gongye he Xingxihua Bu Guanyu Xiada 2015 Nian Diyipi Xitu Shengchan Zongliang Kongzhi Jihua de Tongzhi [Notice of the Ministry of Industry and Information Technology on Issuing the Plan to Control Total Volume of Rare Earth Production for Year 2015]*.Retrieved from http://ycls.miit.gov.cn/n11293472/n11295125/n11299560/16537225.html

PRC Ministry of Land and Resources (MLR). (1999). *Guanyu dui Xitu Deng Bazhong Kuangchan Zanting Banfa Xukezheng de Tongzhi [Notice on Halting the Approval of Mining Licenses for Eight Kinds of Minerals Including Rare Earths]*. Beijing: Department of Deposit of the Ministry of Land and Resources.

PRC Ministry of Land and Resources (MLR). (2000a). *Quanguo Kuangchan Chuliang Huizong Biao [China's Total Mineral Deposit Table]*. Beijing: Department of Deposit of the Ministry of Land and Resources.

PRC Ministry of Land and Resources (MLR). (2000b). *Guanyu Jixu dui Xitu Deng Bazhong Kuangchan Zanting Banfa Xukezheng de Tongzhi [Notice on Continuing the Halt of the Approval of Mining Licenses for Eight Kinds of Minerals Including Rare Earths]*. Beijing: Department of Deposit of the Ministry of Land and Resources.

PRC Ministry of Land and Resources (MLR). (2003). *2003 Nian Zhengdun he Guifan Kuangchan Ziyuan Guanli Zhixu Gongzuo Anpai Yijian [Opinion on the Distribution of Work for Consolidating and Regulating the Mineral Resources Management in 2003]*. Beijing: Department of Deposit of the Ministry of Land and Resources.

PRC Ministry of Land and Resources (MLR). (2010a). *Guanyu Kaizhan Xitu Deng Kuangchan Kaifa Zhixu Zhuanxiang Xingdong de Tongzhi [Announcement of Special Mission of Inspecting the Development of Mineral Resources including the Rare Earths]*. Beijing.

PRC Ministry of Land and Resources (MLR). (2010b). *Nanfang Wu Shengqu Shiwu Shi Xitu Kuangchan Kaifa Jianguan Quyu Lianhe Xingdong Fang'an [rare earth minerals development regulation and regional joint enforcement plan in South China's 5 provinces and 14 cities]*. Retrieved from http://www.mlr.gov.cn/tdzt/kcgl/xtzz/zxdt/201008/t20100827_747389.htm

PRC Ministry of Land and Resources (MLR). (2011, January 17). *Guanyu Sheli Shoupi Xitu Kuangchan Guojia Guihua Kuangqu de Gonggao [Announcement of Establishing the First Batch of National Planning Districts for Rare Earth Mineral Resources]*. Retrieved from http://www.mlr.gov.cn/zwgk/zytz/201101/t20110117_812188.htm

PRC Ministry of Land and Resources (2011, September 26). *Meng Lu Chuan 3 Sheng Qu Qing Xitu Jianguan Lianhe Xingdong Qidong [Inner Mongolia, Shandong and Sichuan 3 Provinces Start Light Rare Earth Regulation Joint Operation]*. Retrieved from http://www.gov.cn/gzdt/2011-09/26/content_1956776.htm

PRC Ministry of Land and Resources. (2012). *Xitu Tankuangquan Caikuangquan Mingdan [List of Rare Earth Exploration Rights and Mining Rights]*. Retrieved from http://www.gov.cn/gzdt/2012-09/13/content_2223862.htm

PRC Ministry of Metallurgical Industry. (1978). *Chengli Baotou Xitu Ni Gongsi de Baogao [Report on Establishing Baotou Rare Earths and Niobium Company]*. Beijing.

PRC Ministry of Metallurgical Industry. (1979). *Xide Tie Fan Tai Xitu Ni Kaocha Baogao [Research Visit Report on Iron, Vanadium, Titanium, Rare Earth and Niobium in West Germany]*. Beijing.

PRC Ministry of Science and Technology (MOST). (1998). *Jishu Chuangxin Gongchen Quyu Shidian Guanli Banfa (Shixing) [Management Guidelines of Technology Innovation Project Pilot Centers (Trial Implementation)]*. Beijing.

PRC Ministry of Science and Technology (MOST). (2008). *Zhengfu Gongzuo Baogao zhong Wen Jiabao Lun Keji yu Chuangxin [Wen Jiabao on Science Technology and Innovation in Report on Chinese Government Work]*. Retrieved from http://www.most.gov.cn/yw/200803/t20080307_59640.htm

PRC Ministry of Science and Technology (MOST), Ministry of Finance (MOF) & State Administration of Taxation. (2008). *Gaoxin Jishu Qiye Rending Guanli Banfa [Criteria for Recongition of High-tech Company]*. Retrieved from http://www.most.gov.cn/fggw/zfwj/zfwj2008/200804/t20080428_61006.htm

PRC Ministry of Science and Technology (MOST). (2011). *Kexue Falv Fagui yu Zhengce Xuanbian: 1985-2008 Nian [Selected Science and Technology Laws and Policies: 1985-2008]*. Beijing: Keji Wenxian Chubanshe [Science and Technical Documentation Press].

PRC Ministry of Science and Technology (MOST). (2012). *Diandong Qiche Keji Fazhan Shi'erwu Zhaunxiang Guihua [12th Five-Year Plan for Electric Vehicle Technology Development]*. Beijing. Retrieved from http://www.most.gov.cn/tztg/201204/W020120503407413903488.pdf

PRC National Development and Reform Commission (NDRC), Ministry of Science and Technology (MOST) & Ministry of Commerce (MOFCOM). (2004). *Dangqian Youxian Fazhan de Gaojishu Chanyehua Zhongdian Lingyu Zhinan (2004 Niandu) [Guidelines for Priority Development of High-tech Commercialization Areas (2004)]*. Beijing.

PRC National Development and Reform Commission (NDRC). (2005). *Chanye Jiegou Tiaozheng Mulu (2005 Nian Ben) [2005 Guidelines of Adjustment to Industry Structures]*. Beijing.

PRC National Development and Reform Commission (NDRC). (2005). *Chanye Jiegou Tiaozheng Mulu (2005 Nian Ben) [2005 Guidelines of Adjustment to Industry Structures]*. Beijing.

PRC National Development and Reform Commission (NDRC). (2008). *Guanyu 2008 Nian Shenhua Jingji Tizhi Gaige Gongzuo de Yijian [Guidelines for Deepening Economic Reform in 2008]*. Retrieved from http://www.jssasac.gov.cn/zcfb/zcfg/200807/t20080731_10155.html

PRC National Development and Reform Commission (NDRC). (2014). *Guojia Yingdui Qihou Bianhua Guihua (2014 -2020 Nian) [National Plan to Address Climate Change (2014-2020)]*.Retrieved from http://www.sdpc.gov.cn/gzdt/201411/W020141104591413713551.pdf

PRC National Development and Reform Commission (NDRC), PRC Ministry of Environmental Protection (MEP) & PRC Ministry of Industry and Information Technology (MIIT). (2015, April 20). *Xitu Yelian Hangye Qingjie Shengchan Pingjia Zhibiao Tixi [Evaluation Indicators System for Clean Production for Rare Earth Smelting Industry]*. Retrieved from http://www.sdpc.gov.cn/zcfb/zcfbgg/201504/W020150420524648629613.pdf

PRC National People's Congress (NPC). (1984). *Zhonghua Renmin Gongheguo Zhuanlifa [Patent Law of the People's Republic of China]*. Retrieved from http://www.law-lib.com/law/law_view.asp?id=2824

PRC National People's Congress (NPC). (1992). *Guanyu Xiuding <Zhonghua Renmin Gongheguo Zhuanlifa> de Jueding [Decision on Revising the Patent Law of the People's Republic of China]*. Retrieved from http://www.wipo.int/wipolex/zh/text.jsp?file_id=198976

PRC National People's Congress (NPC). (2008). *Zhonghua Renmin Gongheguo Zhuanlifa (Xiuzheng) [Patent Law of the People's Republic of China (Revised)]*. Retrieved from http://www.gov.cn/flfg/2008-12/28/content_1189755.htm

PRC State Administration of Industry and Commerce. (1999, August 25). *Guanyu Sheng Yixia Gongshang Xingzheng Guanli Jiguan Shixing Chuizhi Guanli hou Qiye Dengli Guanliquan de Yijian [Announcement on Company Registration Management after the Implementation of Vertical Management of the Administrations of Industry and Commerce below the Provincial Level]*. Retrieved from http://www.saic.gov.cn/zcfg/xzgzjgfxwj/199908/t19990825_46329.html

PRC State Administration of Taxation. (2012, May 16). *Guojia Shuiwu Zongju Gonggao 2012 Nian Di 17 Hao Guanyu Jiang Xitu Qiye Kaiju de Fapiao Naru Zengzhishui Fangwei Shuikong Xitong Hanzi Fangwei Xiangmu Guanli Youguan Wenti de Gonggao [Announcement No. 17 [2012] of the State Administration of Taxation -*

Announcement on Relevant Issues for the Incorporation of Invoices Issued by Rare Earth Enterprises in Administration of the Chinese Character Anti-Counterfeit Project of the Anti-Counterfeit VAT Tax Control System]. Retrieved from http://www.chinatax.gov.cn/n810341/n810765/n812151/n812416/c1083518/content.html

PRC State-owned Assets Supervision and Administration Commission (SASAC). (2006). *Guanyu Tuijin Guoyou Ziben Tiaozheng he Guoyou Qiye Chongzu Zhidao de Yijian [Guiding Opinions of the State-owned Assets Supervision and Administration Commission of the State Council about Promoting the Adjustment of State-owned Capital and the Reorganization of State-owned Enterprises]*. Beijing.

PRC State Commission Office for Public Sector Reform. (2008). *Woguo Xingzheng Guanli Tizhi Gaige Jincheng de Huigu: Xishu 6 Ci Xinzheng Gaige [Review of China's Reform Process in Public Sector Institutional Reform: Details on 6 Bureaucratic Institution Reforms]*. Retrieved from http://politics.people.com.cn/GB/1026/8537797.html

PRC State Council. (1988). *Guowuyuan Guanyu Shenhua Keji Tizhi Gaige Ruogan Wenti de Jueding [State Council Decision on Issues in Advancing Science and Technology Institutional Reform]*. Retrieved from http://www.most.gov.cn/kjzc/gjkjzc/gjkjzczh/201308/P020130823574948122617.pdf

PRC State Council Rare Earth Leadership Group. (1988). *Zhongguo Xitu-1988[Rare Earth in China -1988]*. Beijing.

PRC State Council Rare Earth Leadership Group. (1989). *Zhongguo Xitu - 1989 [Rare Earths in China - 1989]*. Beijing.

PRC State Council Rare Earth Leadership Group & Ministry of Foreign Economy and Trade. (1989). *Guanyu Jiaqiang Xitu Chukou Guanli de Tongzhi [Notice on Increasing Regulation of Rare Earth Export]*. Beijing.

PRC State Council Rare Earth Leadership Group. (1990). *Zhongguo Xitu - 1990 [Rare Earths in China - 1990]*. Beijing.

PRC State Council Rare Earth Leadership Group, National Science and Technology Commission & Ministry of Foreign Trade and Economic Cooperation. (1990, July 10). *Guanyu Xitu Duiwai Hezuo he Jishu Chukou Guanli de Tongzhi [Notice of Regulation on Rare Earth International Cooperation and Technology Export]*.

PRC State Council Rare Earth Leadership Group & State Planning Commission. (1991, October 20). *Guanyu Yinfa<< Tongpei Lizi Xitu Yanghuawu Chanpin Gongxiao Hetong Guanli Zanxing Banfa >> de Tongzhi [Notice on Printing and Distributing Trial Regulations on Production and Market of Ionic Mixed Rare Earth Oxide Products under Instructional Planning].* Beijing.

PRC State Council. (1991, January 15). *Guanyu Jiang Wu Xi Di Lizixing Xitu Kuangchan Liewei Guojia Shixing Baohuxing Kaicai Teding Kuangzhong de Tongzhi [Notice of Tungsten, Tin, Antimony and Ion-adsorption Rare Earths Assigned to the Category of Special Minerals under National Protective Mining]*. Retrieved from http://www.miit.gov.cn/n11293472/n11505629/n11506410/n11514954/n11923841/n11923931/12032066.html

PRC State Council Rare Earth Leadership Group. (1991). *Zhongguo Xitu - 1991 [Rare Earths in China - 1991]*. Beijing.

PRC State Council Rare Earth Leadership Group. (1992). *1992 Nian Zhongguo Xitu Shijian Dashi [Ten Major Events in Rare Earth Industry in China in 1992]*. Beijing.

PRC State Council. (1992, November 9). *Guowuyuan Guanyu Zengjian Guojia Gaoxin Jishu Chanye Kaifaqu de Pifu [Written Reply from the State Council on Establishing New National-level High-Tech Industrial Development Zones]*. Retrieved from http://www.gov.cn/xxgk/pub/govpublic/mrlm/201012/t20101231_63518.html

PRC State Council Rare Earth Leadership Group. (1993). *Zhongguo Xitu - 1993 [Rare Earths in China - 1993]*. Beijing.

PRC State Council. (1996). *Guowuyuan Guanyu "Jiuwu" Qijian Shenhua Kexue Jishu Tizhi Gaige de Jueding [State Council Decision on Advancing Science and Technology Institutional Reform in the 9^{th} Five-Year Plan]*. Retrieved from http://cpc.people.com.cn/GB/64184/64186/66687/4494386.html

PRC State Council. (1998). *Guowuyuan Guanyu Zujian Guojia Youse Jinshu Gongyeju de Tongzhi [Announcement of the State Council on Establishing the Bureau of National Non-ferrous Metals Industry]*. Beijing.

PRC State Council. (1999a). *Guanyu Jiaqiang Jishu Chuangxin, Fazhan Gaogeji, Shixian Chanyehua de Jueding [Decision on Increasing Technology Innovation, Developing High-tech Industries and Achieving Commercialization]*. Beijing.

PRC State Council. (1999b). *Guanyu Zujian Zhongguo Tong Qian Xin Jituan Gongsi Youguan Wenti de Pifu [Response to Relevant Questions about the Establishment of China Copper Lead Zinc Group]*. Beijing.

PRC State Council. (1999c). *Guanyu Zujian Zhongguo Lvye Jituan Gongsi Youguan Wenti de Pifu [Response to Relevant Questions about the Establishment of China Aluminum Group]*. Beijing.

PRC State Council. (1999d). *Guanyu Zujian Zhongguo Xiyou Xitu Jinshu Jituan Gongsi Youguan Wenti de Pifu [Response to Relevant Questions about the Establishment of China Rare Metals and Rare Earth Group]*. Beijing.

PRC State Council. (2000a). *Guanyu Shenhua Keyan Jigou Guanli Tizhi Gaige de Shishi Yijian [Guideline on Deepening Institutional Reform of Scientific Research Institutes]*. Beijing.

PRC State Council. (2000b). *Guowuyuan Guanyu Tiaozheng Zhongyang Suoshu Youse Jinshu Qishiye Danwei Guanli Tizhi Youguan Wenti de Tongzhi [Announcement of the State Council on Relevant Questions about Adjusting the Management System of Central-Government-Owned Non-ferrous Metal Companies and Institutions]*. Beijing.

PRC State Council. (2003). *Guanyu Touzi Tizhi Gaige de Jueding [Decisions of the State Council on Reforming the Investment System]*. Beijing.

PRC State Council. (2010a). *Guowuyuan Guanyu Xiugai <Zhonghua Renmin Gongheguo Zhuanlifa Shishi Xize] de Guiding [State Council Decision on Revising the Patent Law of the People's Republic of China].* Retrieved from http://www.wipo.int/wipolex/zh/text.jsp?file_id=198299

PRC State Council. (2010b). *Guowuyuan Guanyu Cujing Qiye Jianbing Chongzu De Yijian [State Council Recommendations on M&A and restructuring of firms]*. Retrieved from http://www.gov.cn/zwgk/2010-09/06/content_1696450.htm

PRC State Council. (2010c). *Guowuyuan Guanyu Jiakuai Peiyu he Fazhan Zhanluexing Xinxing Chanye de Jueding [Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries]*. Beijing.

PRC State Council. (2011a). *Zhonghua Renmin Gongheguo Ziyuanshui Zanxing Tiaoli [Provisional Regulation of Resource Tax for the People's Republic of China].* Beijing.

PRC State Council. (2011b). *Guowuyuan Guanyu Cujing Xitu Hangye Chixu Jiankang Fazhan De Ruogan Yijian [Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earth Industry]*. Retrieved from http://www.gov.cn/zwgk/2011-05/19/content_1866997.htm

PRC State Development Planning Commission. (2002, August 6). *Waishang Touzi Xitu Hangye Guanli Zanxing Guiding [Interim Provisions on the Administration of Foreign-Funded Rare-Earth Industry]*. Retrieved from http://www.china.com.cn/chinese/PI-c/184362.htm

PRC State Economic Commission, State Planning Commission, State Science and Technology Commission & Ministry of Metallurgical Industry. (1979). *1979-1981 Nian Xitu Tuiguang Yingyong Guihua [1979-1981 Rare Earth Application Promotion Plan]*. Beijing.

PRC State Economic Commission, State Planning Commission & State Science and Technology Commission. (1985). *Zhongguo Xitu Gongye "Qiwu" Fazhan Guihua [7th Five-Year Development Plan of the Chinese Rare Earth Industry]*. Beijing.

PRC State Economic Commission & Ministry of Geology and Mineral Resources. (1987, September 7). *Guanyu Yinfa <<Jiaqiang Woguo Lizi Xifuxing Xitu Kuangshan Kaicai, Shengchan Guanli de Jidian Yijian>> de Tongzhi [Notice of Printing and Distributing Several Recommendations on Mining Exploration, Production and Governance of China's Ionic-Adsorption Type Rare Earth Deposits]*. Beijing.

PRC State Economic and Trade Commission. (1999). *Guanyu Dui Xitu Deng 13 Zhong Shangpin Shixing Chukou Pei'e Youchang Zhaobiao de Tongzhi [Notice on Implementing Fee-based Export Quota Application for 13 Kinds of Products including the Rare Earths]*. Beijing.

PRC State Economic and Trade Commission. (2000a). *Guanyu Zhaizhuangu Qiye Guifan Caozuo he Qianghua Guanli de Tongzhi [Notice of Standardizing Operations and Increasing Management for Debt-Equity Swap Enterprises]*. Beijing.

PRC State Economic and Trade Commission. (2000b). *Guanyu Jiasu Shishi Jishu Chuangxin Gongchen Xincheng yi Qiye Wei Zhongxin de Jishu Chuangxin Tixi de*

Yijian [Advice about Expediting the Implementation of Technology Innovation Projects to Build an Enterprise-focused Technology Innovation System]. Beijing.

PRC State Economic and Trade Commission. (2002a). *Gaunyu Guoyou Dazhongxing Qiye Zhufu Fenli Fuye Gaizhi Fenliu Anzhi Fuyu Renyuan de Shishi Banfa [Notice of Implementation Methods Regarding the Separation of Major and Minor Operation Units and the Placement of Surplus Workers in the Restructuring of Large and Medium State-owned Enterprises]*. Beijing.

PRC State Economic and Trade Commission. (2002b). *Guojia Jingmao Wei Gonggao 2002 Nian Di 77 Hao Gongbu 2003 Nian Zhongyao Gongyepin Chukou Pei'e Zongliang Fenpei Yiju he Shenqing Chengxu [State Economic and Trade Commission No. 77 Announcement in 2002: Announcement of Year 2003 Export Quota, Total Volume Distribution Criteria and Application Procedure for Export of Important Industrial Products]*. Beijing.

PRC State Economic and Trade Commission. (2002c). *Guanyu Zujian Quanguoxing Xitu Qiye Jituan Youguan Wenti de Tongzhi [Notice on Relevant Issues in Establishing National Rare Earth Industry Conglomerates]*. Beijing.

PRC State Economic and Trade Commission, Ministry of Finance, People's Bank of China. (2003). *Guanyu Jinyibu Zuohao Guoyou Qiye Zhaiquan Zhuan Guquan Gongzuo de Yijian [Opinions on Exerting Further Efforts in the Work of Debt-Equity Swap of the State-owned Enterprise]*. Beijing.

PRC State Planning Commission. (2000). *Zhongguo Xitu Gongye Shi'wu Fazhan Guihua [10th Five-Year Plan for China's Rare Earth Industry]*. Beijing.

PRC State Science and Technology Commission/ (1997). *Jishu Chuangxin Gongchen Gangyao [Guidelines of National Technology Innovation Projects]*. Retrieved from http://old.gdstc.gov.cn/plan/kj6.html

Pei, M. (2006). The dark side of China's rise. *Foreign Policy, 153*(March/April), 32-40.

Pei, M. (2008). *China's Trapped Transition: The Limits of Developmental Autocracy*. Cambridge, MA: Harvard University Press.

Perry, E. J. (1994). Shanghai's strike wave of 1957. *The China Quarterly, 137*, 1-27.

Polanyi, K. (1944). *The Great Transformation: The Political and Economic Origins of Our Time*. Boston, MA: Beacon Press.

Polinder, H. et al. (2006). Comparison of direct-drive and geared generator concepts for wind turbines. *IEEE transactions on Energy conversion*, *21,* 3, 725-733.

PwC. (2014). *Waiting out uncertainty: Junior mine 2014.* Retrieved from https://www.pwc.com/ca/en/junior-mining-headquarters/publications/pwc-junior-mine-2014-10-en.pdf

Qian, Y. & Weingast, B.R. (1996). China's Transition to Markets: Market-Preserving Federalism, Chinese Style. *Journal of Policy Reform*, *1,* 149-185.

Qian, Y. & Roland, G. (1998). Federalism and the Soft Budget Constraint. *American Economic Review 88*(5), 1143-1162.

Quan, J. (2003). Dui Yadi Dijia Zhaoshang Yinzi Wenti de Sikao [Thoughts on Lowering Land Price to Attract Industry Projects and Investments]. *Guotu Ziyuan [Land & Resources]*, 2, 35-37.

Rademaker, J. H., Kleijn, R., & Yang, Y. (2013). Recycling as a Strategy against Rare Earth Element Criticality: A Systemic Evaluation of the Potential Yield of NdFeB Magnet Recycling. *Environmental Science & Technology*, 130903123155005. http://doi.org/10.1021/es305007w

Rare Earth Net. (2005). Jiangxi Sheng Ganzhou Shi Xitu Kuangye Youxian Gongsi Chengli [Jiangxi Province Ganzhou Prefecture Rare Earth Mining Limited Company Established]. *Xitu Xinxi [Rare Earth Information]*, 1,

Rare Earth Office of the State Planning Commission. (1993). *Zhongguo Xitu - 1993 [Rare Earths in China - 1993]*. Beijing.

Rare Earth Office of the State Planning Commission. (1994). *Zhongguo Xitu - 1994 [Rare Earths in China - 1994]*. Beijing.

Rare Earth Office of the State Planning Commission. (1995). *Zhongguo Xitu - 1995 [Rare Earths in China - 1995]*. Beijing.

Rare Earth Office of the China National Nuclear Company. (1995). Hegongye Zonggongsi "Bawu" Xitu Kaifa Chengji he "Jiuwu" Shexiang [China National Nuclear Company's "8th Five-Year" Rare Earth Development Progress and "9th Five-Year" Prospects]. *Xitu Xinxi [Rare Earth Information]*, 10, 2-3.

Rare Earth Office of the State Development Planning Commission. (1999). *Zhongguo Xitu - 2000 [Rare Earths in China - 1999]*. Beijing.

Rare Earth Office of the State Development Planning Commission. (2000). *Zhongguo Xitu - 2000 [Rare Earths in China - 2000]*. Beijing.

Rare Earth Office of the National Development and Reform Commission (NDRC). (2005). *2005 Nian Zhongguo Xitu Shijian Dashi [Top ten events in China's rare earth industry in 2005]*. Beijing.

Rare Earth Office of the National Development and Reform Commission (NDRC). (2006). *2006 Nian Zhongguo Xitu Shijian Dashi [Top ten events in China's rare earth industry in 2006]*. Beijing.

Ren, H. (2013, December 24). Zhishi Chanquan Shou Zhi: Xitu Ziyuan Daguo Ruhe Baituo Zhuan Xiaoqian Ganga [Intellectual Property Constraint: How Rare Earth Resource Power Can Break the Dilemma of Marginal Earnings]. *Xinhua*. Retrieved from http://big5.xinhuanet.com/gate/big5/jjckb.xinhuanet.com/2013-12/24/content_483763.htm

Renewable Energy Policy Network for the 21st Century (REN21). (2013). *Renewables 2013 Global Status Report.* Paris, France: REN21. Retrieved from http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf

ResearchInChina. (2012). *Global and China Permanent Magnet Industry Report, 2012*. Beijing. Retrieved from http://www.researchinchina.com/Htmls/Report/2013/6714.html

ResearchInChina. (2014). *Global and China NdFeB Industry Report, 2014-2018*. Beijing. Retrieved from http://www.researchinchina.com/Htmls/Report/2014/7951.html

Resnick Institute. (2011). *Critical Materials for Sustainable Energy Applications.* Pasadena, CA: California Institute of Technology. Retrieved from http://resnick.caltech.edu/docs/R_Critical.pdf

Rhone-Poulenc. (1996). Luona Pulangke zai Zhongguo de Xitu Fazhan Zhengce [Rhone-Poulenc's Strategy in Developing Rare Earths in China]. *Zhongguo Xitu Xuebao [Journal of the Chinese Rare Earth Society]*, *14* (1), 95-96.

Ridder, M. de. (2013). *The Geopolitics of Mineral Resources for Renewable Energy Technologies*. The Hague Center for Strategic Studies. Retrieved from http://www.hcss.nl/reports/the-geopolitics-of-mineral-resources-for-renewable-energy-technologies/127/.

Rithmire, M. E. (2014). China's "New Regionalism": Subnational Analysis in Chinese Political Economy. *World Politics 66*(1), 165-194.

Roddan, M. (2015, August 18). Lynas open to takeover offers after debt deal. *The Australian.* Retrieved from http://www.theaustralian.com.au/business/mining-energy/lynas-open-to-takeover-offers-after-debt-deal/story-e6frg9df-1227487499479

Roskill. (1997). Rare Earths: Restructuring in the Japanese Industry Is Not Yet Complete. In Roskill (Ed.), *Roskill's Letter from Japan (January 1997)* (pp. 2-3). London.

Rotberg, R. I. (2003). Failed States, Collapsed States, Weak States: Causes and Indicators. In R. I. Rotberg (Ed.), *State Failure and State Weakness in a Time of Terror* (pp. 1-26). Washington D.C.: Brookings Institution Press.

Rotberg, R. I. (2004). The Failure and Collapse of Nation-States: Breakdown, Prevention, and Repair. In R. I. Rotberg (Ed.), *When States Fail: Causes and Consequence* (pp. 1-50). Princeton, NJ: Princeton University Press.

Ruttinger, L. & Feil, M. (2010*). Sustainable Prevention of Resource Conflicts: New Risks from Raw Materials for the Future? Case Study and Scenarios for China and Rare Earths (Section Report 3.4)*. Berlin: Federal Environment Agency (Umweltbundesamt). Retrieved from https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4108.pdf

Sally, R. (2002). *Classical Liberalism and International Economic Order: Studies in Theory and Intellectual History*. London: Routledge.

Schuler, D., Buchert, M., Liu, R., Dittrich, S. & Merz, C. (2011). *Study on Rare Earths and their Recycling*. Darmstadt: Oeko Institute. Retrieved from http://www.oeko.de/oekodoc/1112/2011-003-en.pdf

Seaman, J. (2010). *Rare earths and clean energy: Analyzing China's Upper Hand*. Paris: Center for Asian Studies at the French Institute of International Relations. Retrieved from http://www.ifri.org/en/publications/enotes/notes-de-lifri/rare-earths-and-clean-energy-analyzing-chinas-upper-hand

Shapiro, J. (2000). *Mao's War Against Nature: Politics and the Environment in Revolutionary China.* Cambridge: Cambridge University Press.

Shen, X. & Zhao, Y. (2012, August 20). Xitu Baoweizhan [Rare Earth Defense]. *Zhongguo Xinwen Zhoukan [China Newsweek]*, 30, 3.

Shenzhen Business Daily. (2001, October 30). Meigguo Gongsi Daxing Susong Xitu Yongciye Jiang Liangji Fenhua [U.S. Companies Filing Lawsuits; Rare Earth Permanent Magnet Industry Expected to Have Widening Gaps]. *Xitu Shichang [Rare Earth Market]*, p.2.

Shi, C. (1985). Riben Sanjin Jinshu Kuangye Gongsi Changqi Cong Zhongguo Jinkou Xitu Yuanliao [Japan’s Mitsui Metal & Mining Company Makes Long-term Imports of Rare Earth Refined Ores from China]. *Xitu [Chinese Rare Earths]*, 1, 79-80.

Shirk, S. L. (1993). *The political logic of economic reform in China* (Vol. 24). Berkeley, CA: University of California Press.

Shue, V. (1995). State sprawl: the regulatory state and social life in a small Chinese city. In D. S. Davis, R. Kraus, B. Naughton & E. J. Perry (Eds.), *Urban spaces in contemporary China: The potential for autonomy and community in post-Mao China* (pp.90-112). Cambridge: Cambridge University Press and Woodrow Wilson Center Press.

Shumsky, T. (2011, September 12). Testing Their Metals. *Wall Street Journal*. Retrieved from http://online.wsj.com/article/SB10001424053111903639404576516012428805034.html

Si, N. (1998, April 21). SOE Reform Guidelines Restated. *China Daily*. Retrieved from http://www.chinadaily.com.cn/epaper/html/cd/1998/199804/19980421/19980421004_3.html

Sichuan News. (2005). Nanbei Xitu Jituan de Wuyan Jieju [Unspoken End of the North and the South Rare Earth Conglomerates]. *Xitu Xinxi [Rare Earth Information]*. Retrieved from http://www.cre.net/show.php?contentid=953

Sinha, A. (2003). Rethinking the developmental state model: Divided leviathan and subnational comparisons in India. *Comparative Politics*, 35 (4), 459-476.

Skocpol, T. (1979). *States and Social Revolutions: A Comparative Analysis of France, Russia, and China.* Cambridge: Cambridge University Press.

Skocpol, T. (1985). Bringing the State Back In: Strategies of Analysis in Current Research. In P. B. Evans, D. Rueschemeyer & T. Skocpol (Eds.), *Bringing the State Back In* (pp.3-38). New York, NY: Cambridge University Press.

Smith, A. (1887). *An Inquiry Into the Nature and Causes of the Wealth of Nations.* Edinburgh: Thomas Nelson and Sons.

Snyder, R. (2001). *Politics after Neoliberalism: Reregulation in Mexico*. Cambridge: Cambridge University Press.

So, A. Y. (2007). Peasant conflict and the local predatory state in the Chinese countryside. *The Journal of Peasant Studies*, *34*(3-4), 560-581.

Solinger, D. J. (1991). *From lathes to looms: China's industrial policy in comparative perspective, 1979-1982*. Stanford, CA: Stanford University Press.

Song, Y. (2011). 15 Shi Qianshu 5 Fen Xieyi, Nanfang Xitu Quyu Jianguan Jixu Tuijing. [15 cities signed 5 agreements, rare earth regional regulation in the South progresses]. *The Economic Observer.* Retrieved from http://www.eeo.com.cn/2011/0602/202695.shtml

Southern Weekly. (2005). Shui Wei Shengcun Huanjing Maidan: Guangdong Sheng Xingning Shi Zoutao Cun 20 Nian Baoshou Xitu Kaicai Wuran Zhi Ku [Who Pays for the Living Environment: Zoutao Village in Xingning Prefecture, Guangdong Province Suffered 20 Years of Pollution from Rare Earth Mining]. *Xitu Xinxi [Rare Earth Information]*, 4, 34-35.

Steinmo, S., Thelen, K. & Longstreth, F. (Eds.) (1992). *Structuring Politics. Historical Institutionalism in Comparative Analysis*. Cambridge: Cambridge University Press.

Su, W. (2009). *Zhongguo Xitu Chanye Jingji Fenxi Yu Zhengce Yanjiu [Economic Analysis and Policy Research of China's Rare Earth Industry]*. Beijing: Zhongguo Caizheng Jingji Chubanshe [China Finance & Economic Publishing House].

Sui, Z. (1994). Guowuyuan Xitu Bangongshi Zhaokai Quanguo Xitu Hangye Jishu Jinbu Huiyi [State Council Rare Earth Office Hosted National Rare Earth Industry Technology Progress Conference]. *Xitu Xinxi [Rare Earth Information]*, 1, 45.

Sun, Z. (Ed.). (2001). *Baotou Kexue Jishu Zhi [Chronicle of Science and Technology in Baotou]*. Baotou, Inner Mongolia: Neimenggu Renmin Chubanshe [Inner Mongolia People's Press].

Sun, P. (2006). Is the state-led industry restructuring effective in transition China? Evidence from the steel sector. *Cambridge Journal of Economics, 31* (4), 601-624.

Sundial Intellectual Property Law Firm. (2014). Chutan Woguo Meiguo Ouzhou Riben Yiji Zhongguo Dalu duiyu Nizhi Sangshi Xinyingxing Guiding de Yitong [Commonalities and Differences between Taiwan, the U.S., Europe, Japan and Chinese Mainland regarding the Regulations on the Loss of Novelty]. Retrieved from http://www.sundial.com.tw/service4file/201404%20Vol%201603R.pdf

Szamosszegi, A., & Kyle, C. (2011). *An analysis of state-owned enterprises and state capitalism in China*. Capital Trade, Incorporated for US-China Economic and Security Review Commission. Retrieved from http://www.uscc.gov/sites/default/files/Research/10_26_11_CapitalTradeSOEStudy.pdf

Tabuchi, H. (2010, October 5). Japan Recycles Minerals from Used Electronics. *New York Times*, p. B1.

Takaki, J. (1995, October 17). わが国レアアース産業の現状と展望 [Current Situation and Future Outlook of Japan's Rare Earth Industry]. In Information Center of the Japan Metals and Mining Corporation (Ed.), *Proceedings of the 7th Sino-Japan Rare Earth Communications Meeting* (pp.33-37). Tokyo.

Teng, X. (2010, August 30). ZhongRi Jingji Gaoceng Duihua: Liangguo Reyi Xitu Wenti [Sino-Japan Economic High-level Dialogue: Two Countries Discuss Rare Earth Issue]. *People's Daily*. Retrieved from http://japan.people.com.cn/35463/7122635.html

Thelen, K. (1999). Historical institutionalism in comparative politics. *Annual Review of Political Science*, 2 (1), 369-404.

Thelen, K. & Steinmo, S. (1992). Historical institutionalism in comparative politics. In S. Steinmo, K. Thelen, F. Longstreth (Eds.), *Structuring Politics. Historical Institutionalism in Comparative Analysis* (pp. 1–32). Cambridge: Cambridge University Press.

Tilly, C. (Ed.). (1975). *The Formation of National States in Western Europe*. Princeton, NJ: Princeton University Press.

Tilly, C. (1985). War Making and State Making as Organized Crime. In P. B. Evans, D. Rueschemeyer & T. Skocpol (Eds.), *Bringing the State Back* In (pp.169-186). Cambridge: Cambridge University Press.

Ting, M. H., & Seaman, J. (2013). Rare Earths: Future Elements of Conflict in Asia? *Asian Studies Review*, *37*(2), 234–252.

Unger, J., & Chan, A. (1995). China, corporatism, and the East Asian model. *The Australian Journal of Chinese Affairs*, *33*, 29-53.

U.S.-China Business Council. (2013). China's Strategic Emerging Industries: Policy, Implementation, Challenges & Recommendations. Retrieved from https://www.uschina.org/sites/default/files/sei-report.pdf

U.S. China Business Council. (2014). National Development and Reform Commission. Retrieved from https://www.chinabusinessreview.com/sites/default/files/NDRC%202014%2004.pdf

U.S. Department of Energy (DOE). (2010, December). *Critical Materials Strategy*. Retrieved from http://energy.gov/sites/prod/files/edg/news/documents/criticalmaterialsstrategy.pdf

U.S. Department of Energy (DOE). (2011a). *2011 Critical Materials Strategy*. Retrieved from http://energy.gov/sites/prod/files/DOE_CMS2011_FINAL_Full.pdf

U.S. Department of Energy (DOE). (2011b). *One Million Vehicles By 2015: February 2011 Status Report.* Retrieved from http://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.

pdf

U.S. House Committee on Natural Resources. (2010, November 17). USGS: America Has Abundant Supply of Rare Earth Elements. Retrieved from http://naturalresources.house.gov/uploadedfiles/11.17.10-abundantrareearthelements.pdf

U.S. Geological Survey (USGS). (2012). *Mineral Commodities Summaries: Rare Earths 2012.* Washington, D.C.: USGS.

U.S. Geological Survey (USGS). (2013). *Global Rare Earth Oxide Production Trends.* Washington, D.C.: USGS.

U.S. Geological Survey (USGS). (2014). *Mineral Commodities Summaries: Rare Earths 2014.* Washington, D.C.: USGS.

U.S. Government Accountability Office (GAO). (2010, April 1st). *Rare Earth Materials in the Defense Supply Chain*. Washington, D.C.: GAO.

Vogel, S.K. (1996). *Freer Markets, More Rules: Regulatory Reform in Advanced Industrial Countries.* Ithaca, NY: Cornell University Press.

Vogel, S.K. (2006). *Japan Remodeled: How Government and Industry are Reforming Japanese Capitalism.* Ithaca, NY: Cornell University Press.

Wade, R. (1990). *Governing the market: Economic theory and the role of government in East Asian industrialization*. Princeton, NJ: Princeton University Press.

Wang, L. (2003). Baogang Xitu Gongyequ Zhouwei Huanjing Fangshexing Wuran yu Fangzhi Duice [Radioactive Pollution in Nearby Environment of Baotou Steel Rare Earths Production Region and Corresponding Solutions]. *Baotou Huanbao [Baotou Environmental Protection], 19* (2-3), 31-37.

Wang, C. (2004). Woguo Xitu Gongye “Shiyiwu” Fazhan Zhanwang [Outlook on the 11th Five-Year Development of China’s Rare Earth Industry]. *Xitu Xinxi [Rare Earth Information],* 10, 7-9.

Wang, C. (2009). Woguo Xitu Gongye Fazhan yu Zhanwang [Our Country's Rare Earth Industry Development and Future Prospects]. *Xitu Xinxi [Rare Earth Information],* 9, 4-8.

Wang, G. (2007). Xitu Yelian "Sanfei" Ji Fangshexing Wuran Xianzhuang Ji Zhili Jianyi [Current Situation and Suggestions for Treatment of the "Three Wastes" and Radioactive Pollution in Rare Earth Smelting]. *Xitu Xinxi [Rare Earth Information],* 8, 19-23.

Wang, H. (1994). *The Gradual Revolution: China's Economic Reform Movement*. New Brunswick, NJ: Transaction publishers.

Wang, J. (2011). *Zhongguo Xitu Baowei Zhan [War of Defending the Chinese Rare Earths]*. Beijing: Zhongguo Jingji Chubanshe [Chinese Economic Press].

Wang, J. (2013). *State-market Interactions in China's Reform Era: Local State Competititon and Global Market Building in the Tobacco Industry.* New York: Routledge.

Wang, J. (2014). Zhang Zhong: Huanbao Kaoyan [Zhang Zhong: Environmental Protection Challenge]. *Zhongguo Jingji he Xinxihua [Chinese Economy and Information],* 3, 34.

Wang, L. (2003). Jishu Chuangxin Gongchen Jie Shuoguo [Significant Results of National Technology Innovation Projects]. *Zhongguo Chuangye Touzi yu Gaokeji [China Venture Capital and High Tech],* 12, 12-14.

Wang, S. (1995). The Rise of the Regions: Fiscal Reform and the Decline of Central State Capacity in China. In A. Walder (Ed.), *The Waning of the Communist State: Economic Origins of Political Decline in China and Hungary* (pp.88-114). Berkeley, CA: University of California Press.

Wang, S., & Hu, A. (1999). *The Political Economy of Uneven Development: The case of China*. Armonk, NY: ME Sharpe.

Wang, S. & Hu, A. (2001). *The Chinese Economy in Crisis: State Capacity and Tax Reform.* Armonk, NY: M.E. Sharpe.

Wang, X. (2001, May 1). Guojiaju Xiemu [End of National Bureaus]. *Caijing*. Retrieved from http://www.chinanews.com/zhonghuawenzhai/2001-05-01/new/19.htm

Wang, Z. & Liu, J. (2012). Baogang Xitu Kaifa Huanjing Wenti Tantao [Analysis on Environmental Issue of Rare Earth Development by Baotou Steel]. *Baotou Huanbao [Baotou Environmental Protection], 28* (3), 23-26.

Weaver, R.K., Rockman, B.A. (Eds.) (1993). *Do Institutions Matter? Government Capabilities in the United States and Abroad*. Washington, D.C.: The Brookings Institution.

Wei, S. J., & Wang, T. (1997). The siamese twins: Do state-owned banks favor state-owned enterprises in China?. *China Economic Review, 8*(1), 19-29.

Wei, X. (2004). Xitu Qiye Qipan Xitu Chukou Pei'e Gaige [Rare Earth Companies Hoping for Reform of Rare Earth Export Quota]. *Xitu Xinxi [Rare Earth Information]*, 10, 16.

Wei, W. (2008). Jiangxi Tongye Jituan Qude Maoniuping Caikuangquan [Jiangxi Copper Corporation Acquired Mining Rights in Maoniuping]. *Sichuan Xitu [Sichuan Rare Earths]*, 2, 24.

Weingast, B. R. (1981). Regulation, reregulation, and deregulation: The political foundations of agency clientele relationships. *Law and Contemporary Problems*, 147-177.

Weingast, B.R. (1995). The Economic Role of Political Institutions: Market-Preserving Federalism and Economic Development. *The Journal of Law, Economics & Organization, 11*(1), 1-31.

Weiss, L. (1998). *The Myth of the Powerless State. Governing the Economy in a Global Era*. Oxford: Polity Press.

Wen, J. (1987). *Dui Xitu Ziyuan Kaifa, Liyong, Guanli de Jidian Jianyi [Several Recommendations on the Exploration, Application and Governance of Rare Earth Resources]*. Beijing: General Office of the Central Committee of the Communist Party of China.

White House. (2012, March 13). President Obama Speaks on Enforcing Trade Rights with China. Retrieved from http://www.whitehouse.gov/photos-and-video/video/2012/03/13/president-obama-speaks-enforcing-trade-rights-china#transcript

Wong, C., Heady, C., & Woo, W. T. (1995). *Fiscal Management and Economic Reform in the People's Republic of China*. Manila: Asian Development Bank.

Wong, C. P. (2000). Central-local relations revisited the 1994 tax-sharing reform and public expenditure management in China. Paper for the International Conference on "Central-Periphery Relations in China: Integration, Disintegration or Reshaping of an Empire?" Chinese University of Hong Kong, March 24-25.

Woo-Cumings, M. (Ed.). (1999). *The Developmental State*. Ithaca, NY: Cornell University Press.

World Bank. (2002). *China National Development and Sub-national Finance: A Review of Provincial Expenditures.* Washington D.C.: The World Bank.

World Bank. (2015). *China Economic Update – June 2015*. Washington D.C.: The World Bank.

World Trade Organization (WTO). (2010). *World Trade Report 2010*. Retrieved from http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report10_e.pdf

Wright, T. (2012). *The Political Economy of the Chinese Coal Industry: Black Gold and Blood-stained Coal.* London and New York: Routledge.

Wübbeke, J. (2013). Rare earth elements in China: Policies and narratives of reinventing an industry. *Resources Policy, 38*(3), 384-394.

Wu, J. & Ma, L. (2009). Does Government Performance Really Matter? An Event History Analysis of the Promotion of Provincial Leaders in China. Paper presented at the 10th Public Management Research Association Conference, October 1-3, 2009, John Glenn School of Public Affairs, Ohio State University, Columbus, Ohio.

Xiao, F. (Ed.). *Guangdong Sheng Xitu Chanye Jishu Luxiantu [The Rare Earth Industry Technology Roadmap of Guangdong Province]*. Guangzhou, China: Huannan Ligong Daxue Chubanshe [South China University of Technology Press].

Xin, T. (1984). Gai Xiaguan Yiji Bi Xiaguan Liangji Hao [It is Better to Switch from

Two-level Donward to One-level Downward]. *Zhongguo Laodong [China Labor]*, 15, 4-5.

Xinhua. (2004, April 4). Hu Jingtao: Kexue Fazhanguan shi Wodang Tichu de Xin Zhongda Zhanlue Sixiang [Hu Jingtao: Scientific Outlook on Development is the Party's New Strategic Ideology]. Retrieved from http://news.xinhuanet.com/newscenter/2004-04/04/content_1400182.htm

Xinhua. (2005a). *Di Qi Ge Wunian Jihua (1986-1990) [The 7th Five-Year Plan (1986-1990)]*. Retrieved from http://news.xinhuanet.com/misc/2005-10/07/content_3590245.htm

Xinhua. (2005b). *Di Jiu Ge Wunian Jihua (1996-2000) [The 9h Five-Year Plan (1996-2000)]*. Retrieved from http://news.xinhuanet.com/misc/2005-10/07/content_3590247.htm

Xinhua. (2006a, December 19). Guoziwei: Guoyou Jingji Ying Baochi dui 7 ge Hangye de Juedui Kongzhili [SASAC: State Sector should Retain Predominant Control over 7 Industries]. Retrieved from http://www.china.com.cn/policy/txt/2006-12/19/content_7527663.htm

Xinhua. (2006b, December 5). Xitu Chanpin Chukou Pei'e Daomai Changjue [Rampant Illegal Trade of Rare Earth Export Quota]. Retrieved from http://news.xinhuanet.com/mrdx/2006-12/05/content_5437919.htm

Xinhua. (2008). China's 4 trillion Yuan stimulus to boost economy, domestic demand. Retrieved from http://news.xinhuanet.com/english/2008-11/09/content_10331324.htm

Xinhua. (2009). Yangqi Jiakuai Zichan Buju Chongzu Zhenghe Tisu [Central SOEs Speed up on Asset Consolidation and Mergers]. Retrieved from http://news.xinhuanet.com/fortune/2009-06/19/content_11568832.htm

Xinhua. (2011). *Guoming Jingji He Shehui Fazhan Di Shier Ge Wunian Guihua Gangyao [Outline of the 12th Five-year Plan of National Economic and Social Development]*. Retrieved from http://www.gov.cn/2011lh/content_1825838.htm

Xinhua. (2011, August 31). Xitu Zhangjia Boji Woguo Zhanlue Xingxing Chanye [Rare Earth Price Increase Affects China's Strategic and Emerging Industries]. Retrieved from http://news.xinhuanet.com/energy/2011-08/31/c_121937165.htm

Xinhua. (2013, March 11). Naxie Nian, Naxie Xiaoshi de Buwei [Those Years, Those Disappeared Ministries and Commissions]. Retrieved from http://guoqing.china.com.cn/2013-03/11/content_28197619.htm

Xiong, B. (2004). Shuli he Luoshi Kexue Fazhanguan Shixian Xitu Gongye Kechixu Fazhan [Uphold and Implement the Scientific Outlook on Development to Achieve the Sustainable Development of the Rare Earth Industry]. Presentation at the 2004 National Conference of Rare Earth Office Directors.

Xu, C. (1984). Guanyu Bianzhi "Qiwu" Quangguo Xitu Gongye Fazhan Guihua Wenti [Issues about Drafting the 7th Five-Year National Rare Earth Industry Development Plan]. In The Editorial Board of China Society of Rare Earths Yearbook (Ed.), *China Society of Rare Earths Yearbook 2012* (p.53). Beijing: China Society of Rare Earths.

Xu, D. (2011). Xitu Zhenghe Zhi Ju [Situation of Rare Earth Industry Restructuring]. *Zhongguo Youse Jingshu [China Non-ferrous Metals]*, 21, 32-33.

Xu, L., Liu, M., & Lin, Y. (1999). Xitu Kuang Kaicai dui Tudi Ziyuan de Yingxiang ji Zhibei Huifu [The Influence of Rare Earth Mining on Land Resources and Revegetation]. *Nongcun Shengtai Huanjing [Rural Eco-environment], 15* (1), 14-17.

Xu, G., Li, B. & Yan, C. (1985). Chuanji Cuiqu Lilun de Jinzhan ji Qi Zai Xitu Gongyi Zhong de Yingyong [Improvement of the Countercurrent Extraction Theory and its Applications in Rare Earth Industry Technology]. *Xitu [Rare Earth],*1, 56-67.

Yang, D. L. (1996). *Calamity and Reform in China: State, Rural Society, and Institutional Change Since the Great Famine.* Stanford, CA: Stanford University Press.

Yang, D. L., & Wei, H. (1996). Rising sectionalism in China. *Journal of International Affairs, 49*, 456-477.

Yang, B. (1996). Lun Gongshang Lingdao Ganbu "Xiaguan Yiji" de Kaohe Gongzuo [On "One-level Downward" Performance Reviews of Industry and Commerce Cadres]. *Fujian Luntan (Jingji Shehui Ban) [Fujian Tribune. A Economic and Social Monthly]*, 6, 105-106.

Yang, D.T. & Zhou, H. (1999). Rural-urban disparity and sectoral labour allocation in China. *The Journal of Development Studies, 35*(3), 105-133.

Yang, X. (2009). Xu Zhihong Xiansheng Fangtan Lu [Interview with Prof. Xu Zhihong]. *Zhongguo Kexueyuan Guocheng Gongcheng Yanjiusuo Dongtai [Newsletter of the Institute of Process Engineering of the Chinese Academy of Sciences]*, 221, 13-18. Retrieved from http://www.ipe.cas.cn/cxwh/chbw/200909/P020090930606735182313.pdf

Yang, Y., Liang, Q. & Li, M. (2012, April 9). Gongxinbu Chen Xitu Wuran Daijia Chumu Jingxing [Ministry of Industry and Information Technology Remarks that Consequence of Rare Earth Pollution is Shockingly Huge]. *Jingji Cankaobao [Economic Information Daily]*. Retrieved from http://jjckb.xinhuanet.com/

Yang, D. (2013). The Development Strategy and Policy System Construction of China's Rare Earth Industry. *Contemporary Economy & Management, 35* (8), 66-71.

Yang, S., Xiao, Z. & Li, P. (2003). Zhongguo Guojia Shenji Wenti Wenjuan Diaocha Baogao [Survey Report on Issues in China's National Auditing Institution]. *Shenji Yanjiu [Auditing Research]*, 2, 11-15.

Yang, S. & Xiao, Z. (2008). *Zhongguo Guojia Shenji Tizhi Wenti: Shizheng Diaocha yu Lilun Bianxi [Issues in China's National Auditing Institution: Empirical Research and Theoretical Analysis]*. Beijing: Zhongguo Caizheng Jingji Chubanshe [China Fiscal and Economic Press].

Yap, S. (2011). Huiyi Wode Fuqing Yap Chu-Phay [Memory about My Father Chu Phay Yap]. Beijing: Chinese Academy of Sciences. Retrieved from http://www.cas.cn/zt/kjzt/zgchy/dybf/201111/P020111115399933464078.pdf

Ye, Q. (1989). *Jianchi Zhili Zhengdun he Quanmian Shenhua Gaige Fangzhen Tuidong Xitu Hangye Jiankang Fazhan [Adhere to Strategies of Governance and Consolidation and Comprehensive Deepening Reform to Promote the Healthy Development of Rare Earth Industry]*. Speech at Di'erci Quanguo Xitu Gongzuo Huiyi [2nd National Rare Earth Working Conference]. December 19, Beijing.

Ye, Y. (2015, April 29). Huanbaobu Chongqi "Lvse GDP" Shanxi Ceng Bei Lingdao Yaoqiu Chongsuan [Ministry of Environmental Protection Restarts "Green GDP" Shanxin Province Leaders Used to Require Data Revision]. Hong Kong: Pheonix Television. Retrieved from http://news.ifeng.com/a/20150429/43662614_0.shtml

Yen, W.M., Shionoya, S. & Yamamoto, H. (Eds.). (2006). *Phosphor Handbook (Edition 2).* Baca Raton, FL: CRC Press.

Yi, P. (2002). Woguo Difang Shenji Tizhi Gaige Celue Yanjiu [Research on China's Local Auditing Institution Reform]. *Shenji Yanjiu [Audit Research]*, 6, 41-44.

Yu, F. (2006). Tudi Tiaokong Jidai Tudi Chuizhi Guanli Tizhi Jinyibu Wanshan [Land Management Urgently Needs Improvement of the Vertical Management System of Land Use]. Beijing: Information Center of the Ministry of Land and Resources. Retrieved from http://www.mlr.gov.cn/pub/gtzyb/tuditiaokong/zjgd/t20061016_76820.htm

Yuan, C. (2009). Zhongguo Xitu Ziyuan Kaicai Liyong Xianzhuang ji Fazhan Celue Fenxi [Current Situation of China's Rare Earth Resource Extraction and Utilization and Analysis on Development Strategies]. *Sichuan Xitu [Sichuan Rare Earth]*, 1, 6-10.

Yusoff, M. & Latifah, A. (2002). Rare Earth Processing in Malaysia: Case Study of ARE and MAREC plants. *Proceedings of the Regional Symposium on Environment and Natural Resources, 1,* 287-295. April 10-11, Kuala Lumpur.

Zeng, X. (Ed.) (1985). *Zhongguo Xitu Gongye Bianlan [An Overview of the Chinese Rare Earth Industry]*. Beijing: Quanguo Xitu Tuiguang Yingyong Lingdao Xiaozu Bangongshi [National Rare Earth Applications Promotion Leadership Group Office].

Zhang, Y. (1965). *Guojia Kewei Fuzhuren Zhang Youxuan Zai Di'erci "415" Huiyi Shang De Zongjie Baogao [Closing Speech by Zhang Youxuan, Vice Director of the State Science and Technology Commission at the 2nd "415" Conference]*. April 24, Baotou, Inner Mongolia.

Zhang, A. (2014). WTO Caiding Yinfa de Sikao - Chengwei Xitu Qiangguo Zui Zhongyao [Thoughts Triggered by the WTO Ruling – Paramount Imprtance of Becoming a Strong Nation in Rare Earths]. *Xitu Xinxi [Rare Earth Information]*, 4, 30-32.

Zhang, B., Lu, K., King, K., Wei, W., & Wang, W. (1982). Rare Earth Industry in China. *Hydrometallurgy*, 9, 205-210.

Zhang, P., Li, B., Ye, D., & He, Y. (1985). Mianhuai Daoshi Ho Tsuolin Jiaoshi [Memory of Professor Ho Tsolin (1900-1967)]. *Yanshi Xuebao [Acta Petrologica Sinica]*, 4, 87-90.

Zhang, C., & Heller, T. C. (2007). Reform of the Chinese electric power market:

economics and institutions. In D. Victor & T.C. Heller (Eds.), *The Political Economy of Power Sector Reform* (pp. 76-108). Cambridge: Cambridge University Press.

Zhang, G. (2010, October 14). 3 Nian Jin Chahuo Zousi Xitu 1.6 Wan Dun, Haiguan Jicha Libucongxin [Anti-Smuggling in 3 Years Resulted in Just 160000 Tons of Rare Earth Intercepted; Customs Inspection Does not Match its Ambition]. *Meiri Jingji Xingwen [National Business Daily],* Retrieved from http://www.drcnet.com.cn

Zhang, L. (2012). Sulian Zhuanjia Zai Zhongguo Kexueyuan – Dui 1950 Niandai Zhong Su Liangguo Kexueyuan Jiaoliu Yu Hezuo De Lishi Kaocha [Soviet Union Experts at the Chinese Academy of Sciences – Historical Research on Exchanges and Collaboration between the Soviet Union Academy of Sciences and Chinese Academy of Sciences in the 1950s]. *Kexue Wenhua Pinglun [Science & Culture Review], 9* (2), 54-71.

Zhang, L., Wang, L., Bai, L., Zhang L., & Wang, W. (2000). Baotou Baiyun Kuangqu Jumin Siwang Diaocha [Investigation of Deaths of Residents of Baiyun-ebo Mining District in Baotou]. *Baotou Huanbao [Baotou Environmental Protection], 16* (3-4), 39-47.

Zhang, Y. & Huang, Z. (2011, August 30). Fujian Feifa Daocai "Xitu" Pinfa Huanjin Zhibei Zao Pohuai [Rampant Illegal Rare Earth Mining in Fujian Leads to Environmental and Vegegation Degradation]. China News Service. Retrieved from http://www.chinanews.com/gn/2011/08-30/3293653.shtml

Zhao, X. (2003). Zhongguo Nanfang Xitu Jituan Choubei Gongzuo Qidong [Planning for South China Rare Earth Corporation Group Started]. *Youse Jinshu Gongye [Non-ferrous Metals Industry],* 3, 72.

Zheng, C. (1984). Shilun Woguo Zhuanlifa de Tedian [Analysis on the Special Aspects of the Patent Law of China]. *Xuexi yu Sikao [Learning and Thinking],* 6, 55-58.

Zhong, J. (1994). Zhong Ri Xitu Yongciti Jiage ji Yingyong Bijiao [Comparison of Chinese and Japanese Rare Earth Permanent Magnets in Prices and Applications]. *Xitu Jinzhan [Progress in Rare Earths],* 9, 8-10.

Zhou, C. (1993). Rare earth industry of China. *Journal of Alloys and Compounds, 192*, 111-113.

Zhou, L. (2004). Jinsheng Boyi zhong Zhengfu Guanyuan de Jili yu Hezuo – Jian Lun Woguo Difang Baohu Zhuyi he Chongfu Jianshe Changqi Cunzai de Yuanyin [The Incentive and Cooperation of Government Officials in the Political Tournaments: an Interpretation of the Prolonged Local Protectionism and Duplicative Investments in China]. *Jingji Yanjiu [Economic Research Journal]*, 6, 33-40.

Zhou, C. (2005). Zhongguo Qiye Zhanlue Biange Guocheng Yanjiu: Wukuang Jingyan ji Yiban Qishe [Research on the Process of Change in Chinese Company Strategies: the China Minmetals Experience and its Generally Applicable Lessons]. *Guanli Shijie [Management World]*, 12, 123-136. Retrieved from http://cf.lcchina.org.cn/docbak/f/7/6/297470_518364f81ef76.pdf

Zhou, J. (2006, September 6th). Fang Shexing Wuran Bijin Baotou [Radioactive Waste in Baotou]. *Pheonix News Weekly*. Retrieved from http://www.phoenixtv.com/phoenixtv/72991079409909760/index.shtml

Zhou, L. (2007). Zhongguo Difang Guanyu de Jinsheng Jinbiaosai Moshi Yanjiu [Governing China's Local Officials: An Analysis of Promotion Tournament Model]. *Jingji Yanjiu [Economic Research Journal], 42* (7), 36-50.

Zhou, T. & Xia, X. (2008). Woguo Guoyou Qiye Gaige yu Fazhan 30 Nian [30 Years of Reform and Development of China's SOEs]. In D. Zhou (Ed.), *Zhongguo Gaige Kaifang 30 Nian (1978-2008) [30 Years of China's Reform and Opening Up (1978-2008)]*. Beijing: Shehui Wenxian Chubanshe [Social Science Academic Press]. Retrieved from http://theory.people.com.cn/GB/49154/49155/8057946.html

Zhou, D. (2013, March 28). Rare Earth Permanent Magnet Market Has Strong Potential. *China Non-ferrous Metal News*, p.7.

Zhu, J., Ye, Q., Huang, Y. (2014). Wo Yu Zhongguo De Xitu Yanjiu Yu Chanye-Xu Guangxian Fangtan [Me and China's Rare Earth Research and Industry: Interview with Xu Guangxian]. *Keji Daobao [Science and Technology Review], 32* (10), 15-19.

Zweig, D. (2002). *Internationalizing China: Domestic Interests and Global Linkages*. Ithaca, NY: Cornell University Press.

Zysman, J. (1983). *Governments, Markets and Growth: Finance and the Politics of Industrial Change*. Ithaca, NY: Cornell University Press.

Zysman, J. (1994). How Institutions Create Historically Rooted Trajectories of Growth. *Industrial and Corporate Change*, *3*(1), 244-283.